WESTERN REGION LIBRARY

Environment Canada Parks

Environnement Canada Parcs

Special Resources of Banff National Park

Banff National Park, Warden Service

Canada

SPECIAL RESOURCES

OF

BANFF NATIONAL PARK

Peter L. Achuff
10730-126 Street
Edmonton, Alberta

Ian Pengelly
Cliff White
Warden Service
Banff National Park

March 1986

Table of Contents

EXECUTIVE SUMMARY i
FIGURES iii
TABLES v
PREFACE vii
1. INTRODUCTION 1
1.1 Background and Objectives 1
1.2 Definitions and Criteria 1
1.2.1 Physical and Biological Features 1
1.2.2 Cultural Resources 2
2. METHODS 3
2.1 Information Sources 3
2.2 Data Storage and Access 3
3. PHYSICAL FEATURES 6
3.1 Bedrock Geology 6
3.1.1 Natural Bridge 6
3.1.2 Igneous Dike 6
3.1.3 Castleguard Cave 6
3.2 Surficial Geology 7
3.2.1 Canyons 7
3.2.2 Loess Deposition Sites 8
3.2.3 Neoglacial Landscapes 9
3.2.4 Hoodoos 9
3.3 Fossils 9
3.4 Soils 10
3.4.1 Subalpine Cryosolics — Permafrost 10
3.4.2 Subalpine Chernozemics 10
3.5 Hydrology 11
3.5.1 Springs 11
3.5.2 Waterfalls 13
3.5.3 Lakes 14
3.5.4 Streams 16
3.5.5 Glaciers 17
3.5.6 Management Considerations 18
4. BIOLOGICAL FEATURES 21
4.1 Plants 21
4.1.1 Rare Vascular Plants 21
4.1.2 Other Significant Vascular Plants 33
4.1.3 Vegetation Communities 35
4.2 Animals 40
4.2.1 Invertebrates 40
4.2.2 Fish 41
4.2.3 Amphibians and Reptiles 42
4.2.4 Birds 43
4.2.5 Mammals 55
4.3 Ecologically Important Habitats 69
4.3.1 Mineral Licks 70
4.3.2 Elk Seasonal Ranges 70
4.3.3 Sheep Seasonal Ranges 76
4.3.4 Deer Seasonal Ranges 79
4.3.5 Goat Winter Range 79
4.3.6 Wildlife Migration Corridors 82
4.3.7 Waterfowl Staging Areas 85
4.3.8 Waterfowl Nesting Areas 85
4.3.9 Dipper Winter Areas 85
4.3.10 Black Bear Den Areas 86
5. ECOLOGICAL LAND CLASSIFICATION UNITS 88
5.1 Montane Ecosites 88
5.1.1 Garonne 1 (GA1) 88
5.1.2 Hillsdale 4 (HD4) 88
5.1.3 Patricia 3 (PT3) 88
5.2 Lower Subalpine Ecosites 89

5.2.1 Bow Valley 3 (BV3) 89
5.2.2 Ishbel 3 (IB3) 89
5.2.3 Moraine Lake 2 (ML2) 89
5.2.4 Verdant 2 (VD2) 89
5.3 Upper Subalpine Ecosites 89
5.3.1 Azure 1 (AZ1) 89
5.3.2 Nigel 1 (NG1) 90
5.3.3 Num-Ti-Jah 3 (NT3) 90
5.3.4 Whitehorn 2 (WH2) 90
6. CULTURAL RESOURCES 91
6.1 Prehistoric Cultural Resources 91
6.1.1 Low Elevation Sites 91
6.1.2 Mid-Elevation Sites 97
6.1.3 Upper Elevation Sites 97
6.2 Historic Cultural Resources 97
6.2.1 Fur Trading Period Sites (ca. 1775 - 1850) 101
6.2.2 Prospecting and Early Railroad Period Sites (1850 - 1886) 102
6.2.3 Early Park Period (1887 - 1910) 102
6.2.4 Post-1910 Sites 102
6.3 Management Considerations 103
7. NATURAL AREAS OF SIGNIFICANCE 105
7.1 Introduction 105
7.2 Area Descriptions 105
7.2.1 Bow Lake 105
7.2.2 Carrot Creek 105
7.2.3 Cascade - Flints Park 105
7.2.4 Castleguard Meadows 107
7.2.5 Clearwater River 107
7.2.6 Graveyard Flats 107
7.2.7 Hillsdale 107
7.2.8 Indian Grounds 107
7.2.9 Johnston Canyon 107
7.2.10 Lake Louise 107
7.2.11 Lake Minnewanka 108
7.2.12 Marvel Lake 108
7.2.13 Mount Norquay 108
7.2.14 Panther River 108
7.2.15 Parker Ridge 108
7.2.16 Saskatchewan Crossing 108
7.2.17 Sawback Range 109
7.2.18 Scotch Camp 109
7.2.19 Siffleur River 109
7.2.20 Skoki 109
7.2.21 Spray Sixteen Mile 109
7.2.22 Sulphur Mountain 109
7.2.23 Sunshine Meadows 109
7.2.24 Tunnel Mountain 110
7.2.25 Vermilion Lakes 110
7.2.26 Vermilion Pass 110
7.2.27 Ya Ha Tinda 110
7.3 Management Considerations 110
8. CONCLUSIONS AND RECOMMENDATIONS 112
8.1 Introduction 112
8.2 Montane Ecoregion of the Bow Valley 112
8.3 Other areas and features 113
8.3.1 Middle Springs 113
8.3.2 Lakes 113
8.3.3 Rare Plants 113
8.3.4 Vegetation Communities 113
8.3.5 Ecological Land Classification Units 113
8.3.6 Siffleur Caribou Herd 114
8.3.7 Sunshine Meadows 114
8.3.8 Prehistoric Sites 114

8.4 Monitoring and Research Recommendations 114
8.4.1 Monitoring 114
8.4.2 Research Studies 115
8.5 Zoning 115
LITERATURE CITED 117

EXECUTIVE SUMMARY

The objectives of this report are to: 1) systematically identify the special physical, biological and cultural resource features of Banff National Park (BNP), 2) delineate their locations, 3) describe current conditions and threats to features, and 4) recommend management actions, where appropriate. The criteria of *rarity*, *fragility*, *ecological importance* and *scientific value* were used to select special features. The study began at the individual *feature* level and proceeded to the recognition of *natural areas of significance* based on combinations of special features in an area.

Special bedrock geological features include natural bridges, an igneous dike and Castleguard Cave. Castleguard Cave is among the finest examples of alpine karst anywhere and contains rare and outstanding cave features and invertebrate animals. Surficial geologic features include canyons, loess (a fine, silty material deposited by wind) deposition sites, neoglacial landscapes which have only recently emerged from beneath glacial ice, and hoodoos. Two sites in BNP, one near Massive and the other near Redearth Creek, contain Triassic fish fossils which are rare and of scientific value. Two kinds of soils are restricted to the Front Ranges – Cryosolics, soils containing permafrost, and Chernozemics which develop under Subalpine grasslands. Significant hydrologic features include springs, waterfalls, lakes, streams and glaciers.

Seventy-four rare vascular plants are known from the park, although little is known of their population size, areal extent or life history. An additional 41 plant species reach the edge of their geographic range in BNP and are significant scientifically. Fifteen vegetation types are significant due to their small areal extent (Montane grasslands and dry forests, aspen forests and loess deposition forests) or restriction to a portion of the park (Front Ranges, northern BNP, southern BNP).

Five species of rare or scientifically important invertebrate animals occur in the park, including one species which is known only from Castleguard Cave. Three fishes are special features: Westslope Cutthroat Trout is native but has been greatly reduced by introduced species, Bull Trout (formerly called Dolly Varden) which has declined in numbers recently, and the Banff Longnose Dace which is endemic to the Cave and Basin Hotspring drainage and may now be extinct. Spotted frogs, long-toed salamanders and wandering garter snakes are either rare or uncommon and with a restricted distribution in the park. Twenty-one species of birds are rare residents, twenty-nine are rare migrants, four are uncommon with restricted distributions and one is of scientific interest because of its high altitude nesting. Four Bird Communities are special features because of their restriction primarily to the Montane Ecoregion of the lower Bow Valley.

Sixteen mammal species are rare and another three species are special due to restricted ranges either in BNP or internationally. Ten *ecologically important habitats* are recognized which are portions of the annual habitat requirement of a species that are restricted in distribution or amount, or are threatened by human activities. These include: ungulate mineral licks, elk, sheep, goat and deer seasonal ranges, wildlife migration corridors, waterfowl staging and nesting areas, Dipper wintering areas and black bear den areas.

Ecological land classification units (Ecosites), based on characteristic combinations of landform, soil and vegetation, that occupy limited areas (<320 ha) or are known from only one tract in the park are considered special resources. Three of these Ecosites are in the Montane Ecoregion, four in the Lower Subalpine and four are in the Upper Subalpine.

Cultural resources are divided into *prehistoric* which predate European contact with local native peoples about 1775, and *historic*, those after 1775. The earliest human evidence in BNP is about 10,500 years ago. Numerous prehistoric sites are known but the significance of most of them will not be clear until they are investigated further. Many important sites are concentratrated at low elevations along the Bow, Red Deer and North Saskatchewan river valleys. Numerous historic features have also been catalogued and although not all historic features can be preserved, significant sites should be retained to interpret the various historic periods.

Twenty-seven *natural areas of significance* were recognized where combinations of special features occur. All contain more than one special feature, although not all special features are within a natural area of significance. The areas are: Bow Lake, Carrot Creek, Cascade-Flints Park, Castleguard Meadows, Clearwater River, Graveyard Flats, Hillsdale, Indian Grounds, Johnston Canyon, Lake Louise, Lake Minnewanka, Marvel Lake, Mount Norquay, Panther River, Parker Ridge, Saskatchewan Crossing, Sawback Range, Scotch Camp, Siffleur River, Skoki, Spray Sixteen Mile, Sulphur Mountain, Sunshine Meadows, Tunnel Mountain, Vermilion Lakes, Vermilion Pass and Ya Ha Tinda.

The Montane Ecoregion of the Bow Valley contains the greatest concentration of special features in BNP. It has also been most heavily impacted by human activity and is most likely to be proposed for additional development and user impact. Protection of these special resources should receive the highest priority and will require careful, innovative management. Of particular importance are: the Banff Longnose Dace, waterfowl on Vermilion Lakes, moose in the Bow Valley, black bears, and wildlife migration corridors and elk calving areas around the townsite.

Other important topics which should receive special attention include: the Middle Springs, recreational use of lakes, rare plants, vegetation communities and ecosites, the Siffleur caribou herd and Sunshine Meadows.

Information on most special resources is inadequate and without adequate information, management cannot be well guided. Along with the gathering of additional information, upgrading of information handling systems is needed. Current systems are slow, incomplete, often not current and involve significant lag time. An integrated, park-level, computer-based information system with adequate hardware, software and personnel support is needed.

Additional monitoring is recommended for salamanders, garter snakes, rare birds and soil temperature in permafrost sites. The rationale for monitoring waterfowl and raptors once in five years should be reviewed. High priority research projects include: hydrologic resources, the Castle Mountain Viewpoint fossil site, rare plants, fire ecology of vegetation and wildlife habitat, invertebrates, Bull Trout, deer winter range, the Ya Ha Tinda and prehistoric cultural sites.

FIGURES

1. Watersheds of Banff National Park 4
2. Accipiter observations in Banff National Park, 1975-1984 45
3. Bald Eagle and Osprey observations in the lower Bow Valley 46
4. Falcon observations in Banff National Park, 1975-1984 50
5. Golden Eagle sightings in Banff National Park, 1975-1984 54
6. Wolf observations in Banff National Park, 1975-1984 58
7. Red Fox observations in Banff National Park, 1975-1984 60
8. Wolverine observations in Banff National Park, 1975-1984 62
9. Cougar observations in Banff National Park, 1975-1984 64
10. Caribou observations in Banff National Park, 1975-1984 65
11. Grizzly bear observations in Banff National Park, 1975-1984 68
12. Wildlife mineral licks in Banff National Park, 1975-1984 71
13. Fall elk ranges in Banff National Park, 1975-1984 72
14. Winter (Dec - Mar) bighorn sheep observations in Banff National Park, 1975-1984 77
15. Summer deer observations in Banff National Park, 1975-1984 80
16. Winter deer observations in Banff National Park, 1975-1984 81
17. Winter mountain goat observations in Banff National Park, 1975-1984 83
18. Wildlife migration corridors near Banff townsite 84
19. Black bear observations in Banff National Park, 1975-1984 87
20. Prehistoric sites in Banff National Park 92
21. Historic sites in Banff National Park 98
22. Natural areas of significance in Banff National Park 106

TABLES

1. Subalpine permafrost sites in Banff National Park 11
2. Significant springs in Banff National Park 12
3. Natural mineral licks used by ungulates in Banff National Park 73
4. Elk winter ranges and numbers in Banff National Park and adjacent provincial lands 75
5. Bighorn sheep winter ranges and populations in Banff National Park, March 1985 78
6. Prehistoric sites of Banff National Park and the Ya Ha Tinda Ranch 93
7. Historic sites of Banff National Park 99
8. Natural areas of significance and degree of threat 111

PREFACE

The authors are very aware of the incompleteness of this study. Our limited knowledge of the features of Banff National Park and their occurrence, both in and out of the park, makes this report only a step along the way to a fuller understanding of these special features. We hope that by selecting these features, excluding some, including others, we will stimulate other workers to disagree with, supplement and revise our findings. We welcome this and request that people with additional information or ideas contact us so that we can expand our knowledge of these features and thus better manage and conserve them.

We gratefully acknowledge the help of the following people and agencies who responded to our requests for information and many of whom reviewed earlier drafts of this report:

Agriculture Canada - G.M. Coen, B.D. Walker
Banff National Park, Warden Service - especially, B. Brown, T. Davidson, K. Everts, G. Fortin, D.C. Harvey, P. Jacobson, R. Kunelius, D. Mickle, T. Skjonsberg, G.W. Vroom, A.W. Westhaver
Bow Valley Naturalists - D. McIvor, M. McIvor
Canadian Wildlife Service - G.L. Holroyd, J.G. Stelfox, G.C. Trottier
Jasper National Park - K.J. Van Tighem
National Museums of Canada - G.W. Argus, D.E. McAllister
Parks Canada, Western Regional Office - D. Fedje, G. Harrison, R. Hooper, B. Leeson, D. McDonough, D. Poll, K. Seel, B. Yeo
Provincial Museum of Alberta - J.O. Hrapko
Tyrrell Museum of Palaeontology - D. Brinkman, A.F. Muhammad
University of Alberta - J.R. Butler, D. MacIsaac, J.G. Packer, N.W. Rutter, M.V.H. Wilson
University of Calgary - S. Herrero
and H. Flygare, D. Hamer, J. Kansas and W. McLauchlin.

This report was prepared under the terms of Parks Canada contract KBP0705 to the senior author. The views and recommendations expressed in this report are those of the authors' and do not necessarily reflect the policies of Parks Canada.

1. INTRODUCTION

1.1 Background and Objectives

Many features in Banff National Park (BNP) are of special significance in the park and many are also significant regionally, nationally and internationally. Although the value of these features is generally recognized, no systematic effort has been made to identify, describe, delineate or manage these special resources. The ecological land classification of BNP (Holland and Coen 1982, Holroyd and Van Tighem 1983) dealt, by design, primarily with extensive, common features and consequently, special features received relatively little emphasis. This study deals primarily with the special features at the other end of the spectrum.

Current management of special features is primarily reactive or mitigative. Special features have been adversely affected by poorly located facilities and inappropriate activities. Examples include recreational development on the grasslands at the Indian Grounds, introduction of tropical fish into the Cave and Basin spring, a commercial group camp near the only known active wolf den in BNP and horse-supported group camps in fragile Alpine meadows.

Impacts on these special features sometimes have been addressed through the Environmental Assessment and Review Process (EARP) (Westhaver 1984). However, the sheer volume of data, inadequate data evaluation capability, information gaps and time limitations all make adequate impact assessment difficult. Additionally, on-going activities have not been subject to EARP evaluation. Therefore, establishment of an effective system of preventive management rather than reactive or mitigative measures is necessary for the proper management of special resources.

The objectives of this report are to: 1) systematically identify the special physical, biological and cultural resource features of BNP, 2) delineate their locations, 3) describe current conditions and threats to features, and 4) recommend management actions, where appropriate. Information gaps which prevent adequate description and evaluation of features are identified and recommendations are made for further action.

1.2 Definitions and Criteria

Special resources were divided into three categories: physical features, biological features and cultural features. These were then considered in combination as natural areas of significance (section 7).

1.2.1 Physical and Biological Features

The following criteria were used to identify special features in the physical and biological categories.

Rarity: A rare feature or species is generally known from a small number of sites (usually <10), has a restricted geographic range, or may occur sparsely over a larger area. Rare species have a small population size and are often at the edge of their geographic range. Species or features may be rare in a park, regional or national context.

Fragility: Fragile features are susceptible to change from human impact and are generally sensitive to small amounts of human disturbance.

Ecological Importance: Ecologically important features are plant or animal populations with restricted distributions or key habitats. Key habitats include: 1) areas of limited extent which are critical to life cycle requirements of species, 2) areas characterized by an unusual abundance or diversity of species, and 3) areas that maintain ecosystem integrity by connecting otherwise isolated habitats.

Scientific Value: Features of scientific value provide important opportunities for scientific study or monitoring. Such a feature may be, for example, an intact ecosystem that functions as an ecological benchmark, an area of interpretive value, or one that is important in understanding natural processes. Biological or physical features which reach a geographical range boundary within BNP also meet this criterion. Features at the edge of their range are often most sensitive to environmental changes and thus are ideal for monitoring and understanding natural controlling factors.

1.2.2 Cultural Resources

Cultural resources were divided into *prehistoric* features, up to 1775, and *historic* features, after 1775. All known cultural features are listed here and evaluated as to significance and disturbance by criteria in section 6. Many sites are not well known and their significance is not clear.

2. METHODS

The study began at the *feature* level — the individual species population, plant community, soil or geomorphic phenomenon, cultural resource site. Using the definitions and criteria above, special features in the park were identified. The characteristics and location of each feature were described and the feature was assessed in term of its significance, current condition and threat. Higher levels of integration — Ecosites, an ecological land classification unit — were then considered based on the combinations of features they contain. This then lead to the recognition of *natural areas of significance* which should receive special management consideration. Such management may include zoning, management guidelines specific to the feature or area, such as access or activity control, or relocation of current activities to reduce impact and monitoring. Recommendations for management were made where appropriate and possible.

Special features were not rated as to *degree* of rarity, fragility, ecological importance or scientific value. Such a rating of comparative significance, for example as between a rare plant species, ecologically important sheep winter range and scientifically valuable fish fossils, is of doubtful validity. All features meeting the criteria for special resources should be conserved with equal care. Priorities for management are better based on degree of threat to special features. Thus, the *natural areas of significance* were rated by degree of threat (section 7.3) and comments on threats to particular special features were made where possible.

2.1 Information Sources

A preliminary set of identification criteria and list of special features were drawn up by the authors in conjunction with the Warden Service in BNP. The list was then circulated for comment to other Parks Canada staff, federal government and university research scientists, and other knowledgeable people. These contacts were, in many cases, followed up with interviews or further correspondence. A literature review of both published and unpublished information was also done.

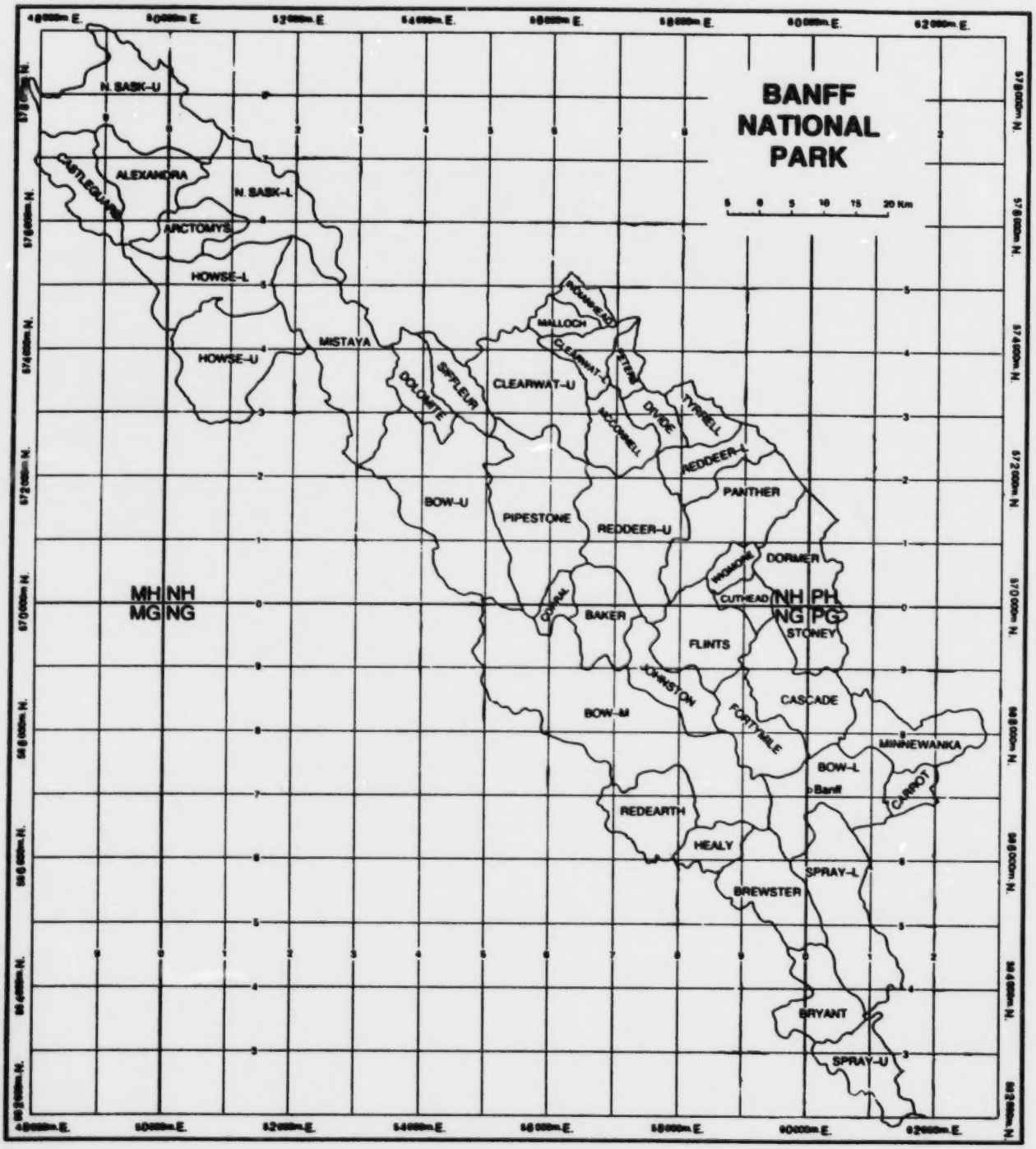
Some field investigations were made during July - September 1985, although the time available was extremely limited. Computerized data bases on landform, soil, vegetation and wildlife from the ecological land classification (Holland and Coen 1982, Holroyd and Van Tighem 1983) were also utilized extensively. The wildlife data base includes information which has been continuously added since completion of the ecological land classification (Warden Wildlife Files 1977 - 1985). Much of this information is organized by watershed (Fig. 1).

The information on cultural resources was derived largely from inventories done by the Archaeological Research Section and the Historic Architecture Section of Parks Canada, Western Regional Office, Calgary. Other sources included the Whyte Museum of the Canadian Rockies in Banff, various consultants' reports, often funded by Parks Canada, and the knowledge of Parks Canada staff.

2.2 Data Storage and Access

A file of information for each special feature and area was established from the information sources described above. These files contain the most detailed information on the resource including some confidential locational information. The files are maintained by the Warden Service of BNP for both detailed documentation and active resource monitoring purposes. The information is in the form of both hard copy and computer disk. Access to the files by qualified personnel is administered by the Warden Service.

Fig. 1. Watersheds of Banff National Park



3. PHYSICAL FEATURES

3.1 Bedrock Geology

The features described in this section are rare, of scientific value and, in one case, of ecological importance, since Castleguard Cave contains key habitat for two rare invertebrate species (section 4.2.1).

3.1.1 Natural Bridge

Natural bridges are formed by water erosion when a stream, which is cutting a channel in bedrock weakened by fractures or faulting, cuts a lower channel beneath the former stream bed, thus leaving part of the former bed bridging the new stream course. Some of these in BNP are far above present streams, such as the Goats Eye arch on Goats Eye Mountain or the arch at the north end of the Sundance Range (Vroom 1986), and were likely formed during the Rocky Mountain Orogeny millions of years ago. Others, such as the natural bridge near Red Deer Lakes, are younger, having been formed by rapid downcutting of post-Pleistocene streams. There are only a few natural bridges in BNP but these are relatively secure from adverse impact presently.

3.1.2 Igneous Dike

Igneous rocks are those that at one time were molten. They became molten deep below the Earth's surface and then flowed upward where they cooled. Most of BNP contains sedimentary bedrock and exposures of igneous bedrock are very rare. The only large body of igneous rock in the Canadian Rockies is the Ice River complex in Yoho National Park (Tera 1982) and northern Kootenay National Park (Achuff *et al.* 1984). In BNP, the only known outcrop of igneous rock is a small body of *diorite* exposed in a road-cut about 1 km south of the southern Bow Lake viewpoint along Highway 93 (Baird 1977). This rock appears to be a small dike formed when molten rock intruded into the surrounding bedrock.

3.1.3 Castleguard Cave

Castleguard Cave is near the head of the Castleguard River in northwestern BNP. Two decades ago, the cave was virtually unknown except to a few guides, outfitters and tourists who explored the first 60 m of the entrance passage where a vertical drop of 10 m stopped them (Ford 1968). The first serious exploration began in 1967 when Derek Ford and students from McMaster University made systematic searches in the Alberta Rockies for caves. During three visits in July and August, the cave was explored for 9 km. The last exploration nearly ended in tragedy when the entrance passage flooded, blocking the return route. After 24 hours, the water subsided enough for the two explorers to exit but moments after their escape, the water rose 12 m flooding 1 km of passage and didn't subside for at least 19 days (Ford 1968). Since then, exploration has been done in the winter when the risk of flooding is less. To date, only one entrance has been found despite an extensive search in 1969 when several promising sinkholes were excavated with explosives (Thompson 1976).

Additional expeditions for exploration and mapping in 1968 to 1970 extended the length of known passages to 11 km and an ice plug was reached which appears to be the end of the cave. In 1973, a further trip evaluated the discoveries of 1970 and the potential for a movie about the cave. The movie was made in April 1974. A gate was installed at the entrance in 1975 because of fears that ill-equipped and inexperienced people might enter the cave (Thompson 1976).

The cave is an internationally significant karst feature in terms of physical development, diversity of features, and rare and unique cave fauna. Castleguard Cave is developed in the upper part of the flat-lying Cathedral Formation, a middle Cambrian limestone approximately 330 m thick. It is the longest cave in Canada at 16.2 km (Yonge 1983) and, at 350 m (Ford 1973), is the second deepest cave in Canada. The principal passage extends beneath the Columbia Icefield where it is blocked by glacial ice 335 m below the surface of the glacier. A second ice plug in a newly explored passage was found in 1983. Geomagnetically reversed *speleotherms* (stalagmites, stalactites and calcite flowstones) suggest that the main passages were drained by at least 750,000 years BP and possibly before 1,250,000 years BP (Gascoyne *et al.* 1983).

The cave contains 18 km of mapped passages and might well contain over twice that length since major unexplored passages appear to double back toward the entrance. The cave could be one of the longest

systems in the world (Yonge 1983). The Castleguard area is the finest karst region yet described in North America and among the finest examples of alpine karst anywhere in the world (Ford 1969). The cave is very diverse and occurs in flat Alpine topography, whereas most Alpine caves are in steeply dipping rocks.

At an estimated depth of 100 to 250 m below Castleguard Cave is Castleguard II, an inaccessible cave which drains the central portion of the Columbia Icefield to the Big Springs on the Castleguard River. About 6.4 km north of the Castleguard Cave entrance, approximately 100 sinkholes connect to Castleguard III, a cave which also supplies water to the Big Springs (Ford 1969).

It is thought that Castleguard Cave developed as a diversion drain from older caves. The diversion was the result of a very unusual kind of speleogenesis which created a long, unbranched passage beneath a mountain. This unusual development probably resulted from glacial infilling which obstructed the older caves and began the diversion (Ford 1983). Since the original cave was first drained, there have been at least three phases of substantial and prolonged inundation. During each, sequences of varves were deposited, in some places to a depth of 5 m. The mechanism for such periodic, highly turbid flooding, to 300 m deep in one phase, is not understood (Schroeder and Ford 1983).

The cave system contains a notable variety of features. Surficial features near the entrance include many diverse small *karren* (minor solutional forms) and more than 100 sinkholes, ranging from shallow stream sinkholes, subsidence and suffusion sinkholes in till, to shafts more than 30 m deep.

The cave contains the finest stalactites and stalagmites in Canada, precipitates of gypsum, hydromagnesite and other rare cave minerals, and varved clays. Gypsum was not expected to occur at all because the cave is presently so humid and cold (Broughton 1972). At the margins of the receding glaciers are the best examples in the world of subglacial stalagmitic precipitates (Ford 1969). Nests of spherical calcite *pisoletes* (cave pearls) are common in caves. They grow by accretion of calcium carbonate around rolling nuclei. However, nests of cubic pearls are rare and four nests of these occur in Castleguard Cave (Roberge and Caron 1983). Their mode of formation is not known but appears related to freezing and long, stable periods in the cave (Roberge and Caron 1983).

Speleotherms are abundant and often very large in tropical and temperate caves. But in Arctic and Alpine caves, actively growing speleotherms are small and uncommon or absent (Ford 1973). Castleguard Cave is a notable exception to this generalization. In spite of being beneath modern glaciers, it contains small active speleotherms wherever suitable slow seepage and drips of water occur (Atkinson 1983).

Four invertebrate animals are known to occur in the cave. An isopod (*Salmasellus steganothrix*) and an amphipod (*Stygobromus canadensis*) are so different from their southern counterparts that it appears they survived several glaciations in the cave (Pugsley 1983). These two species are discussed further in section 4.2.1 below. Mites were collected on a pool near the ice plugs in 1983 (Pugsley 1983). Worm trails are common but no worms have been collected yet.

3.2 Surficial Geology

The features described in this section are rare and of scientific value.

3.2.1 Canyons

Canyons are primarily a postglacial feature. Following deglaciation, large main valleys such as the Bow Valley and North Saskatchewan Valley were much deeper than side valleys due to the greater erosive power of the main valley glaciers. Tributary streams flowing from these hanging side valleys responded to the break in slope above a main valley by depositing material as a fluvial fan (*e.g.* Healy Creek and Brewster Creek) and sometimes by cutting down the channel to form canyons such as Johnston Creek, Mistaya River or Owen Creek.

Johnston Canyon

Johnston Canyon is on the northeast side of the Bow Valley about 7 km southeast of Castle Junction. The canyon is about 4 km long and is 10 to 100 m deep. It is being actively cut by Johnston Creek into faulted and fractured limestone and dolomite bedrock.

In addition to the gorge itself, the canyon contains *travertine* deposits which are actively forming just below the Upper Falls. This colorful rock is formed when ground water containing dissolved limestone seeps down the south and west face of the canyon wall. Algae, which grow in the seep, concentrate dissolved calcium carbonate from the ground water and deposit it in layers. Spray from the waterfall contributes to the vigorous algal growth by keeping the rock wet and the air humid.

Black Swifts also nest in the canyon as discussed in section 4.2.4 below.

Altrude Canyon

Altrude Canyon, along Altrude Creek west of Castle Junction, has a different genesis than most Rocky Mountain canyons. Altrude Creek has cut down through over 120 m of unconsolidated till, leaving a channel 750 m wide, rather than forming a narrow gorge through rock walls. The volume of water required to erode this amount of material is not easily accounted for since the canyon is near Vermilion Pass and has a very small watershed above it. Indirect evidence indicates that the large volume of water came from meltwater of the retreating Vermilion Pass icefield, approximately 8000 years ago, or from an ice-dammed lake in the upper Vermilion Valley which suddenly collapsed (Cathey 1976).

Altrude Canyon because of its depth, size and being cut into till is unique in BNP and is comparable to the large meltwater canyons on the prairies of southern Alberta.

Other Bedrock Canyons

Three other canyons that are cut into bedrock are also significant in BNP. All three are in the northern part of the park: Owen Creek Canyon east of Saskatchewan Crossing at the BNP boundary, Mistaya River Canyon south of Saskatchewan Crossing, and a canyon of the North Saskatchewan River about 4.5 km below the end of the Saskatchewan Glacier.

3.2.2 Loess Deposition Sites

Loess is a fine, silty material deposited by wind. The source of the material is usually unvegetated areas at the edge of a glacier or in seasonally exposed river channels. In many areas, wind-transported volcanic ash is also part of the deposit. A thin deposit of eolian material is common over much of BNP, mantling other landforms. In only a few locations do thick deposits with distinct surficial landforms of mappable extent occur. These thicker calcareous deposits are mostly Eolian material A which occur on valley floors, benchlands and lower slopes in the Montane Ecoregion (Walker *et al.* 1982). In BNP, these occur most notably near Saskatchewan Crossing and at Devil's Gap, at the east end of Lake Minnewanka. Smaller areas occur near the Banff airfield (Rutter 1972) and along the lower Red Deer River near the BNP boundary. Loess deposition areas often contain the C26 vegetation type (Achuff and Corns 1982) as described below in section 4.1.3.

Loess deposition areas are of limited extent in BNP and are of scientific interest because the loess deposition is currently an active process. A similar area in JNP (Jasper National Park) near Talbot Lake and the Athabasca River is also small.

Saskatchewan Crossing

Loess deposition in the Saskatchewan Crossing area extends from Glacier Lake along the North Saskatchewan River east to the park boundary mostly in tracts of the TA3 and NY3 Ecosites (Holland and Coen 1982). The source of the loess is stream deposits of the Howse River, Glacier River and North Saskatchewan River which are mapped mostly as VL1+SC (stream channel).

Devil's Gap

Devil's Gap is at the east end of Lake Minnewanka and the loess deposition area extends from the park boundary west for about 1 km to an intermittent lake. The area is mapped as SC and partly as HD1 (Holland and Coen 1982). The bed of the intermittent lake is the main source of the eolian material and the prevailing westerly wind deposits the material east of the lake. The material is in the form of dunes which are still actively forming and burying older, vegetated, stable deposits. The new deposits have buried living trees up to 1.5 m deep.

The area is severely disturbed by the diversion of the Ghost River into Lake Minnewanka and from illegal dirt bike and off-road vehicle use. Increased management is necessary, perhaps by increased

patrols or rock and ditch barriers to lessen the amount of off-road vehicle activity in the area.

3.2.3 Neoglacial Landscapes

Neoglacial landscapes are those which have only recently emerged from beneath glacial ice and in BNP are frequently associated with retreating valley glaciers in the Main Ranges. They include both morainal deposits, usually either the Warwick 1 (WW1) Ecosite or Recent Moraine (M), and glaciofluvial deposits, most often the Pipestone 4 (PP4) Ecosite or Recent Stream Channel (SC) (Holland and Coen 1982). These landscapes can often be dated and range from a few tens of years to several hundred (Heusser 1956). There is often a landscape sequence with the youngest, Recent Moraine portions near the glacier, followed by sparsely vegetated WW1 moraine, and with the oldest, PP4 deposits furthest from the ice. Developmental gradients of both vegetation and soil also follow this gradient (Heusser 1956, MacIsaac 1985). Neoglacial landscapes occur mostly in the Main Ranges between Lake Louise and the northern BNP boundary including Bath Creek, Hector Lake, the Howse River - Freshfield Creek - Glacier River area, and especially the Alexandra River - North Saskatchewan River area.

These landscapes are of significant scientific value particularly for studies of glacial geology, geomorphology, paleoenvironments, and vegetation and soil development. Research studies have been done in the past on these landscapes (Heusser 1956) and one is currently underway (MacIsaac 1985).

3.2.4 Hoodoos

Hoodoos are erosional landforms which in BNP are usually developed in glacial deposits by post-glacial water erosion. Differential erosion of the weakly consolidated material leaves pillars and towers in often spectacular forms. Hoodoos are known from a small number of sites in BNP, are fairly fragile and are of scientific interest, as well as being of interpretive value. Perhaps the best known hoodoos are those along the Bow River below Tunnel Mountain. Others occur along the Cascade River near the Cascade Power House, where they are part of the environmental complex associated with the oldest Douglas fir in Alberta (section 4.1.2), on Lake Minnewanka, on the lower Red Deer River below Gable Mountain, and along the lower Clearwater River near Indianhead Creek.

3.3 Fossils

Two sites in BNP contain fossils which are rare and of scientific value. Both sites contain marine fish fossils of Lower Triassic age, about 200 million years ago, in rocks of the Sulphur Mountain Formation, Spray River Group (Wilson 1986). The first is near Massive, about 20 km northwest of Banff along the Bow Valley Parkway, and the second is near the Castle Mountain viewpoint on the Trans-Canada Highway, north of Redearth Creek. Triassic fish fossils are known from only a limited number of sites worldwide (Schaeffer and Mangus 1976) and the good quality of preservation makes these sites even more significant (Wilson 1986). These are two of only four locations in the southern Rocky Mountains where Triassic fish fossils have been found and both contain a very diverse assemblage of species (Brinkman 1986). The other two localities are near Fernie, British Columbia and at Wapiti Lake, British Columbia, southwest of Grande Prairie, Alberta.

The Massive site was first collected about 1910 (Lambe 1914, 1915), although earlier collections of similar fossils from the general area of Johnston Creek may have come from the site (Wilson 1986). The site has been collected periodically since and it is the type locality for at least four fossil fish species (Raymond 1925, Warren 1936, Russell 1951, Schaeffer and Mangus 1976). Collections from the Massive site are deposited at the Banff Museum, University of Alberta, National Museum of Canada and Harvard University. The site also contains fossil ammonites.

The Castle Mountain viewpoint site has been only recently discovered and was evaluated by paleontologists in May 1985 (Wilson 1985). The fossils are in blocks of shale deposited by the Ishbel (Hillsdale) landslide which originated across the Bow River on Mount Ishbel during the Quaternary (Holland and Coen 1982). Although only a short time was spent at the site, it seems to be a rich locality with well preserved fossils (Brinkman 1986). Collections from the site are deposited at Parks Canada in Calgary, the University of Alberta and the Geological Survey of Canada in Calgary (Wilson 1986).

The Castle Mountain viewpoint site will likely be affected by the Phase III twinning of the Trans-Canada Highway and a salvage operation should be done both before and during highway construction (Wilson 1985) to save as many fossils as possible from this very important location.

3.4 Soils

Two kinds of soils in BNP are restricted to the Front Ranges (Holland and Coen 1982). Their total extent is not known but is probably limited. Both seem to be associated with Mesozoic bedrock parent materials, although they occupy very different environments and are at opposite ends of the thermal spectrum. *Cryosolics*, soils containing permafrost, are the coldest soils in BNP while *Chernozemics*, which occur under dry, south-facing grasslands, are among the warmest. The association of these soils with Mesozoic bedrock is intriguing but unexplained.

3.4.1 Subalpine Cryosolics — Permafrost

Permafrost is a condition in which the temperature of the subsurface material has been below 0°C for at least two years (Washburn 1973). Soils that contain permafrost are termed *Cryosolics* in the Canadian soil classification system (CSSC 1978). Permafrost is probably not unusual in the Alpine Ecoregion of BNP, above treeline, but is apparently quite uncommon in the Subalpine Ecoregion, below treeline. The presence of Subalpine permafrost in BNP is one of only a few reported occurrences (Achuff and Coen 1980, 1985) in the world.

Subalpine permafrost in BNP is limited to the Front Ranges north of Stoney Creek and is currently confirmed at 17 sites (Table 1) and suspected at 31 others. The sites are commonly on northerly aspect sites with steep slopes and *Picea engelmannii-Abies lasiocarpa/Salix vestita/Cassiope tetragona/-Hylocomium splendens* forest (C24) (Achuff and Corns 1982). These sites are often mapped as the SF1 Ecosite (Holland and Coen 1982), but not all SF1 tracts contain permafrost or vice-versa.

Data from a site on Mount White monitored since 1978 (Achuff and Coen 1985), indicate that permafrost is a persistent feature under current climatic conditions and has existed at this site for many years. Subalpine permafrost also occurs in the Front Ranges of JNP (Achuff and Coen 1980) but is not yet known from any other locations in Alberta, although it is suspected in Willmore Wilderness Park.

Permafrost sites are extremely sensitive to any surface disturbance which changes the thermal regime. Solifluction and rotational slumping are common on these sites under natural conditions and disturbance will accelerate these processes. Removal of vegetation or surficial soil layers should be avoided, especially by road construction. Trail construction should be very carefully evaluated because these sites are wet and seepy most of the summer.

Additional checking of SF1 and similar tracts for the presence of permafrost should be done since not all tracts have been visited. Continued monitoring of the Mount White site, which was monitored from November 1978 until May 1985, is desirable to evaluate long-term trends in climate and permafrost temperature.

3.4.2 Subalpine Chernozemics

Chernozemic soils have a thick ($\geq$10 cm), dark colored surficial horizon caused by many years of organic matter accumulation from the roots and stems of grasses and forbs. Chernozemics must also meet other chemical, morphological and climatic criteria (CSSC 1978). They occur typically under grassland vegetation in the prairies of western Canada and in warm, dry valley bottoms in the western mountains, such as the Columbia Valley. Soils with thick, dark surficial horizons at higher elevations in the mountains (Subalpine and Alpine Ecoregions) have been classified generally as Brunisolics. This was done particularly because it was thought that the mean annual temperature of these higher elevation soils was likely less than the 0°C required for a Chernozemic.

During the ecological land classification of BNP, the surficial horizons of several Subalpine grassland soils were analyzed and found to meet the chemical and morphological criteria of a Chernozemic. However, since there was doubt about the mean annual soil temperature, they were classified as Brunisolics (Walker *et al.* 1982). Monitoring of the temperature of one of these grassland soils on Mount White was begun in November 1979 and continued until May 1985 (Coen and Achuff 1985) in conjunction with study of a nearby permafrost site described above in section 3.4.1. These data showed a mean annual soil temperature of +1.5°C. Thus, this soil is an Orthic Dark Brown Chernozem.

The extent of Chernozemics in the Front Ranges of BNP can only be estimated at this time in the absence of more soil temperature data. However, based on the Mount White site and other information

Table 1. Subalpine permafrost sites in Banff National Park. Data from Achuff and Coen (1985). SSN = Soil Site Number (Holland and Coen 1982). Soil: BSC = Brunisolic Static Cryosol, GLSC = Gleysolic Static Cryosol, OSC = Orthic Static Cryosol, RSC = Regosolic Static Cryosol, SC = Static Cryosol (CSSC 1978).

SSN	Alt. (m)	Latitude	Soil	Location
WT8130.0	1880	51°20'N	SC	Cascade Mountain
NF8093.0	2380	51°23'N	RSC	Stoney Creek
WT8108.0	2230	51°30'N	RSC	Wigmore Creek
TA8121.0	2030	51°30'N	RSC	Dormer River
TA8121.1	1960	51°30'N	RSC	Dormer River
TA8120.1	2200	51°31'N	SC	Dormer River
WT8112.0	2090	51°31'N	GLSC	Wigmore Creek
WT8094.0	2050	51°32'N	GLSC	Panther Mountain
TA8085.0	2170	51°33'N	RSC	Panther River
WT8104.0	2000	51°34'N	RSC	Panther River
TA8091.0	1900	51°35'N	BRSC	Panther River
TA8091.1	2000	51°35'N	SC	Panther River
BW8102.0	2050	51°38'N	GLSC	Gable Mountain
BW8130.0	1950	51°39'N	OSC	Mount White
GC8043.0	1950	51°39'N	BRSC	Mount White
TA8041.0	2050	51°47'N	GLSC	Peters Creek
NF8028.1	1890	51°55'N	SC	Indianhead Creek

gained during the ecological land classification, Chernozemics can be expected in the Front Ranges in tracts of the GT2, SB5, TR2 and WF7 Ecosites (Holland and Coen 1982) where these units contain the H4, H5 and H14 grassland vegetation types (Achuff and Corns 1982). Many of the Melanic Brunisols of these Ecosites may turn out to be Chernozemics when they are better known.

Soil temperature monitoring at a number of sites with different altitudes, slope angles and aspects would help give a more complete picture of soil temperature and of the extent of Subalpine Chernozemics in BNP. These data, in conjunction with data from the Mount White site, could be used to extrapolate to other sites and would be useful for a variety of purposes.

3.5 Hydrology

Hydrologic features are among the significant natural resources of BNP. Hot springs led to the establishment of Canada's first national park (van Everdingen 1972) and waterfalls of national interest occur in the park (Reilly and Beardmore 1980). Icefields and glaciers continue to attract scientific research, tourism and recreational pursuits (Water Survey of Canada 1982) and the park's lakes and rivers have important ecological, scientific and recreational value.

3.5.1 Springs

Numerous points of concentrated water discharge at the earth's surface occur throughout BNP. These include: karst springs (water flowing from solution features), tectonically controlled springs (water flowing from faults), and quasi-springs (water flowing from surficial deposits) (Ozaray and Barnes 1978). Surveys of BNP springs have been conducted by van Everdingen (1972), Neilson (1975a,b), Ozaray and Barnes (1978), and for the Castleguard River area, Ford (1983). For the purposes of this discussion, significant springs are those with high discharge rates (>4 l/s), hot temperatures (>10°C), or unusual hydro-chemical composition. Table 2 summarizes information on springs that meet these criteria. Quantitative data are lacking for the Bryant Creek, River, Meadow Creek and Artesian springs, but they are thought to meet the criteria. Several springs have received detailed study and are discussed below.

Sulphur Mountain Hot Springs: The hot springs on Sulphur Mountain near Banff townsite are the most famous in Canada. There are eight outlets of hot sulphurous water on Sulphur Mountain: Upper Hot Springs, Kidney Spring, the upper and lower Middle Springs, the upper and lower Pool Springs, Cave Spring, and Basin Spring (van Everdingen 1972). CPR workmen Frank McCabe and William

Table 2. Significant springs in Banff National Park.

Location	Flow (l/s)	Temp. (°C)	Remarks	Reference
Bryant Ck.	—	—	—	Warden Service
Mt. Fortune	—	3.0	high H_2S	van Everdingen 1972
Sulphur Mtn.				van Everdingen 1972
- Upr. Hot Spgs.	9.0	47.3	high SO_4, Ca	
- Kidney Spgs.	1.5	39.2	Mg, HCO_3 in	
- Middle Spgs.	3.8	34.8	all springs;	
- Basin Spg.	11.3	34.5	low to	
- Cave Spg.	18.9	32.8	moderate	
- Pool Spgs.	11.3	32.0	radioactivity	
Vermilion Lakes	12.5	18.5	high NaCl	van Everdingen 1972
L. Minnewanka	23.0	—	—	Ozaray & Barnes 1978
Panther R.	1.0	3.0	moderate H_2S	van Everdingen 1972
Ink Pots	30.0	4.0	low mineral	van Everdingen 1972
No-See-Um Ck.	5.0	—	—	Ozaray & Barnes 1978
Red Deer L.	76.0	—	—	Ozaray & Barnes 1978
Clearwater Pass	6.0	—	—	Ozaray & Barnes 1978
Isabella L.	11.0	—	—	Ozaray & Barnes 1978
Mt. Noyes	8.0	—	—	Ozaray & Barnes 1978
Murchison Ck.	76.0	—	—	Ozaray & Barnes 1978
Mt. Wilson	19.0	—	karst spgs.	Ozaray & Barnes 1978
Mt. Sarbach	30.0	—	—	Ozaray & Barnes 1978
Outram L.	114.0	—	—	Ozaray & Barnes 1978
Forbes Bk.	11.0	—	—	Ozaray & Barnes 1978
Glacier R.	19.0	—	—	Ozaray & Barnes 1978
Arctomys Ck.	27.0	—	—	Ozaray & Barnes 1978
Castleguard R.			karst system	Ford 1983, Smart 1983
- Big Spring	500	1.6	—	
- Eldon Spgs.	50	—	—	
- Cave Spgs.	100	—	—	
- River Spgs.	—	—	—	
- Meadow Ck. Spgs.	—	—	—	
- Artesian Spgs.	—	—	—	
Cascade Mtn.	>5	—	—	Neilson 1975a,b
Duthil	>5	—	—	Neilson 1975a,b

McCardell filed a claim on the springs near the Cave in 1883. Subsequently, recognition of the value of the springs by the Canadian government led to the establishment of *Rocky Mountains Park* in 1885 — Canada's first national park (Byrne 1964).

The source of the hot springs' water may be Sundance Creek (Haites 1959) or it may be from the snowmelt and rainfall on Sulphur Mountain which percolates to a minimum depth of 1260 m before being heated and returned to the surface along the Sulphur Mountain thrust fault (van Everdingen 1972). In either case, the flow of the springs is directly dependent on precipitation. During dry years, such as 1923, the Upper Hot Springs may dry up completely.

Despite only moderate water temperatures, modest radioactivity, and relatively common mineral content (van Everdingen 1972), the springs have gained great popularity, and all have been impacted by development since the 1880's. Currently the Upper Hot Springs and the Cave and Basin Springs have swimming pools. Kidney Springs and Middle Springs were also historically impounded to pipe water to the Banff Springs Hotel and a fish hatchery, respectively. The upper and lower Middle Springs remain the most undisturbed although even they have been greatly changed from their natural condition (van Everdingen 1978). The warm mineral waters and environs of the hot springs provide a unique habitat for rare plants (section 4.1.1), invertebrates (section 4.2.1) and fish (section 4.2.2).

Vermilion Spring: Although the original outlets of the springs on the Third Vermilion Lake have been covered over by road construction, the warm waters continue to keep a sizeable area of the lake free of ice during winter. These springs have a different mineral content and higher radioactivity than the Sulphur Mountain springs (van Everdingen 1972).

Fortune Springs: Emanating near Fortune Warden Cabin on the Spray River, this spring is cold and smells strongly of sulphur. The marshy area below the spring is a favorite watering area for wildlife (van Everdingen 1972).

Panther River Sulphur Springs: Lying near the Panther River at an elevation of 1790 m, these are the highest elevation sulphur springs known in the southern Rocky Mountains (van Everdingen 1972). The water is high in sulphur dioxide and minerals, favoring the growth of bacterial and algal colonies around the outlets. The springs are cold, rarely visited, and have not been greatly disturbed.

Johnston Creek Ink Pots: The Ink Pots have been studied in detail (van Everdingen 1969, 1972) and consist of seven connected pools with a greenish milky appearance, which are on Johnston Creek above the canyon. The water is cold with a low mineral content. A unique circumstance of upward movement of water through a bed of quicksand gives the ponds their particular color. Human trampling has removed vegetation and compacted soils in the area.

Castleguard Springs: Several high volume seasonal springs occur as a result of karst aquifers in the Castleguard Valley (Ford 1983, Smart 1983). Total spring flow in the valley may exceed 2000 l/s. The largest outflow is from Big Spring, which is downhill from the Castleguard Cave entrance (section 3.1.3). Other major springs in the valley include Eldon Springs, Cave Springs, River Springs, Meadow Creek Springs, and Artesian Springs. Smart (1983) traced inflow to the springs from a broad area, including the Saskatchewan Glacier, Castleguard Meadows, and benches on Castleguard Mountain, and concluded that the Castleguard Springs have pronounced diurnal and seasonal fluctuations that are directly influenced by weather patterns in the Columbia Icefields area. Light visitor use has caused little impact to spring outlets.

3.5.2 Waterfalls

Waterfalls are not only a scenic attraction, but also provide a focus for evaluating geological, geomorphic, and hydrologic processes. Common causes of waterfalls include unequal stream erosion, unequal glacial erosion, lowering of stream outlets (hanging valleys), and blocking of stream courses (Reilly and Beardmore 1980). Due to a complex geological and glacial history, BNP has a variety of waterfalls of different origins, heights, and flow volumes. Many are associated with canyons (section 3.2.1). Information on waterfalls in BNP includes Baird (1977), Reilly and Beardmore (1980), Sole (1980) and Warden Service reports. The following descriptions are of well known or significant waterfalls. These falls usually flow year-round, and have either a high summer flow volume (>500 l/s) or exceed 20 m in height.

Bow Falls: Bow Falls is representative of the Rocky Mountain region (Reilly and Beardmore 1980). The falls are approximately 15 m high and result from blockage of an older course of the Bow River to the north of Tunnel Mountain by a glacial moraine (Baird 1977). The falls are a major tourist attraction near Banff townsite, and are surrounded by viewpoints, roads and visitor trails.

Johnston Canyon Falls: Two waterfalls in Johnston Canyon are good examples of differential water erosion of limestone and dolomite which produced the waterfalls. A well-constructed and heavily used trail system winds through the canyon past the falls.

Giant Steps: In Paradise Valley, south of Lake Louise, stream flow over resistant Cambrian quartzite strata has created a notable set of stepped falls. The area around the falls is easily accessible to day hikers but is only lightly impacted.

Falls in the Upper North Saskatchewan Valley: Deep glacial carving through Devonian limestone has caused a number of significant waterfalls along the Icefields Parkway near Nigel Creek (Baird 1977). These include Cirrus Mountain falls (Polar Circus), the Weeping Wall, Glacier Falls, Bridal Veil, Panther Falls, and an unnamed cataract that descends from below Mount Saskatchewan. Most of these falls are easily seen from viewpoints along the highway.

Martin Creek Falls: Unequal glacial erosion has created a string of lakes separated by falls up to 40 m high on upper Martin Creek, a tributary of the Clearwater River. During the summer, the falls have a

high volume due to meltwater from an icefield north of Mount Willingdon. The valley is one of the most lightly visited in the park and the vicinity of the falls remains undisturbed.

Bighorn Falls: Bighorn Falls, although outside BNP near the Ya Ha Tinda Ranch, is representative of Rocky Mountain region waterfalls (Reilly and Beardmore 1980). This 30 m falls results from differential stream erosion across adjacent rock types. A road passes immediately west of the falls, and the area is a popular destination for summer visitors and ice climbers in winter.

3.5.3 Lakes

Lakes in BNP constitute an important ecological, scenic and recreational resource. In general, lakes have always attracted human use and those near roads or trails may be considerably disturbed. Non-native fish have been introduced to many lakes to improve the sport fishery (Ward 1974). Hiking, fishing, photography, and camping have destroyed vegetation and compacted soils along many lake shores (Trottier 1977).

There are 480 lakes and ponds in BNP (Ward 1974). Anderson (1969a) defined a lake as a body of water having a depth >3 m and/or an area >1 ha and provides physical and chemical information for 71 lakes in BNP. Other limnological surveys include Rawson (1939) for 19 lakes, Mayhood and Anderson (1976) of 31 lakes in the Lake Louise area, and Anderson and Donald (1978) of seven lakes in the eastern portion of the park. Unfortunately, these surveys do not provide a consistent data base with which to evaluate the significance of individual lakes. Therefore, this evaluation of BNP lakes is tentative and is based largely on significant physical attributes (*e.g.* geological origin) or scientific value.

Anderson (1969a) classified BNP lakes on a basis similar to that of the ecological land classification (Holland and Coen 1982) into Montane, Subalpine and Alpine. Holroyd and van Tighem (1982) further classified lakes according to aquatic habitat types. These classifications are used below to discuss significant BNP lakes.

Alpine Lakes

Over 100 lakes in BNP lie in the treeless Alpine Ecoregion above about 2300 m, and are ice-free from approximately early July to early October. They are oligotrophic, characterized by low temperatures, short growing seasons, very simple communities, and low primary and secondary production (Anderson 1968). Alpine lakes are not important as ungulate, carnivore, bird, or small mammal habitat (Holroyd and Van Tighem 1983) and tend to be small (<10 ha) and shallow (<15 m) (Anderson 1969a).

Snowflake Lake: Located near Snow Creek Pass south of the Red Deer River, this lake has scientific value. It is at 2320 metres, has an area of 7.1 ha and a maximum depth of 6.1 m (Anderson and Donald 1978). The lake, originally barren of fish, has a long term record of stocking, and has been studied in detail (Anderson 1968). Stocked fish are dying out, and the lake may be returning to its natural state. Anderson and Donald (1978) state: "Because there [are] good base line data for this lake, we strongly recommend that this lake be left unstocked in future and that it be kept as a control and study site." Since the Cascade Fire Road was closed in 1981 the lake is visited less frequently.

Martin Creek Lakes: On upper Martin Creek is a series of three alpine lakes separated by rock cliffs, but connected by waterfalls to form *paternoster lakes* — a pattern resulting from glacial erosion and recession. These lakes are probably the best representative of this feature in BNP. The area is remote and is little disturbed.

Subalpine Lakes

In the Subalpine Ecoregion of BNP there are over 50 lakes. They usually freeze over from mid-October to early November, and break-up from early April to mid-May (Anderson 1969a). Lakes with high meltwater input are usually oligotrophic with low temperatures and production. Lower meltwater input and sheltering from winds has allowed development of a few eutrophic lakes in the Subalpine (Anderson 1969b, Anderson and Donald 1976). Most Lower Subalpine lakes are of low to moderate importance to birds and mammals (Holroyd and Van Tighem 1983).

Wigmore Lake: This lake is probably the highest elevation lake with eutrophic conditions in BNP. This is due to an unusual location in the top of a pass, with low inflow and a shallow depth. The lake provides habitat for muskrats and beaver (Holroyd and Van Tighem 1983).

Moraine Lake: Moraine Lake is a significant national landmark and has scientific and aesthetic value. The lake has an area of 42 ha and a maximum depth of 20 m (Anderson 1969a). The geomorphology of the area and formation of the lake are described by Gardner (1968) and Kucera (1974). The close proximity of the lake to the Wenkchemna Glacier and active talus slopes of the Bow Range provides an excellent example of mountain geomorphic processes. The eastern and northern lake shores are visited by thousands of people annually (Gest 1970), resulting in considerable disturbance to vegetation and soils.

Lake Louise: Since the European discovery of the lake by Tom Wilson in 1882, Lake Louise has been regarded as a scenic treasure of international significance (Whyte and Harmon 1982). The lake area is representative of Rocky Mountain geology (Gardner 1968, Kucera 1974) and is the most accessible glacier-fed lake and glaciated area along the Trans-Canada Highway. The Chateau Lake Louise, at the east end of the lake, is an area visited by hundreds of thousands of people. The heavy use may damage potential fish spawning beds in the outlet stream (Mayhood and Anderson 1976). The west end of the lake remains relatively natural and is the background for millions of pictures.

Herbert Lake: This lake has scientific value due to studies (Anderson 1969b) which show that the lake is moderately eutrophic with low inflow. With an area of 5.7 ha and maximum depth of 13.3 m, it is an excellent Subalpine lake to compare with Snowflake Lake in the Alpine Ecoregion (Anderson 1970). The lake has an unusually high sodium chloride content, possibly due to road salting of the Icefields Parkway (Anderson 1969b). Numerous swimmers and anglers visit the lake in the summer.

Hector Lake: With an area of 550 ha and a maximum depth of 87 m, Hector Lake is the largest of two lakes on the Bow River in BNP. The lake has scientific value due to studies of lakebed sediments (varves) that provide indications of past climatic and glacial history (Smith 1978, Leonard 1981). Hector Lake has not been disturbed by human activity.

Bow Lake: This 270 ha glacially-fed lake lies at the head of the Bow River. It also has scientific value due to glacial history and sedimentation rate studies conducted on it (Kennedy 1975, Leonard 1981). The shores of Bow Lake are disturbed by a picnic area, the Icefields Parkway and Num-ti-jah Lodge. Sewage effluent from the lodge reduces water quality.

Peyto Lake: This blue-green lake is one of BNP's most famous. It is highly representative of glacial lakes in the Rocky Mountain region (Tera 1982). The lake and its source stream have provided locations for research on suspended glacial sediments (Vendl and Smith 1977), sedimentology of glacial deltas (McDonald and Banerjee 1971), and glacial stream discharge (Young and Stanley 1976). Although viewed from a distance by thousands of tourists, the lake itself is infrequently visited and shows few signs of human impact.

Upper Waterfowl Lake: The delta formed by the Mistaya River flowing into the lake is a classic example of a low energy depositional feature. Volcanic ash layers in the delta have allowed detailed dating and determination of depositional rates (Smith 1975). In addition, the surrounding marshy habitat of the lakes is utilized by beaver and muskrat — an uncommon situation in the glacial lakes of the Lower Subalpine (Holroyd and Van Tighem 1983). Waterfowl Lakes Campground lies near the north end of the lake, and the shoreline is visited by hikers and anglers.

Montane Lakes

The Montane Ecoregion of BNP has only a few lakes: Lake Minnewanka, Two Jack Lake, Johnson Lake, Vermilion Lakes, Pilot Pond, and Warden Lake. With the exception of Lake Minnewanka and Two Jack Lake, these lakes are eutrophic with high temperatures, low water renewal rates, and high production. They freeze over by the end of November and thaw by early May (Anderson 1969a). With the exception of Warden Lake and Pilot Pond, the Montane lakes are heavily visited and all have been dammed and had their water level regulated. Given the limited number of Montane lakes and their current degree of impairment, all except Two Jack Lake are considered special resources.

Lake Minnewanka: This is the only cold water, oligotrophic lake in the Montane Ecoregion of BNP, and is the deepest and largest lake in the park. A series of dams constructed from 1911 to 1941 increased the area of the lake to 1860 ha and the maximum known depth to 95 metres (Rawson 1945). Effects of constructing the 1941 dam on the lake's physical, chemical, and biological characteristics have been documented (Rawson 1942, 1945; Cuerrier 1954). Recently, Parks Canada has conducted some test netting of fish populations in the lake (Weibe 1984) which shows that the impact of damming the lake has been greatest in the littoral zone where annual drawdown has destroyed the natural environment.

However the deeper portions of the lake remain productive and support a substantial fishery. Since 1975, BNP has developed numerous campsites along the north shore of the lake. Boating use, particularly overnight cabin cruisers, is increasing. Water sampling in 1975 showed no significant human pollution (Block and Gummer 1979).

Johnson Lake: This warm lake lies in a low elevation Douglas fir forest. Pilot Pond is the only similar lake in BNP, although several comparable lakes occur in JNP. The low elevation and low water input rate have created habitats important to several bird and small mammal species (Holroyd and Van Tighem 1983). The Johnson Lake fishery has been extensively manipulated (Ward 1974) and the water level is controlled by dams at either end of the lake. In summer, it is heavily visited by anglers, picnickers and swimmers. This use has damaged lakeshore vegetation and soils. In February 1986, the dam at the west end of the lake collapsed. Further actions are being considered.

Vermilion Lakes: These lakes are the largest backwater and floodplain water bodies in BNP. Their shallow depths and location in the Montane Ecoregion result in warm temperatures and relatively uncommon benthic vegetation (Anderson 1969a). The lake area provides important mammal and bird habitat (Bow Valley Naturalists 1978, Holroyd and Van Tighem 1983). Fisheries, especially in the Third Lake, have been extensively managed (Ward 1974). Water flow and channel meandering through the lakes was seriously disrupted by construction of the railway in 1882. Subsequently, the lakes were dammed and Fivemile Creek diverted into the Third Lake (Bow Valley Naturalists 1978). Canoers, anglers and wind surfers frequent the lakes.

Pilot Pond: This is a warm kettle lake which is significant because it is the only lake in the Montane Ecoregion of the lower Bow Valley which has not had its water level manipulated by man. The lake was formerly known as Lizard Lake until fish stocking eliminated a population of long-toed salamanders. Angler and hiker visits to the lake cause little disturbance.

Warden Lake: Located two km east of Saskatchewan Crossing, this lake is also a kettle lake with shallow depths and warm temperatures. Although it is easily accessible by trail and has been stocked with trout repeatedly (Ward 1974), it remains relatively pristine compared to other Montane lakes in BNP.

3.5.4 Streams

No comprehensive inventory of streams in BNP exists. Kellerhals *et al.* (1972) provide general geomorphic information for the Bow River and North Saskatchewan River. Mayhood and Anderson (1976) describe limnological conditions in 16 streams near Lake Louise. Mudry and Green (1977) investigated the limnology of Sunshine Creek, Healy Creek and Brewster Creek. Parks Canada (1977, 1978a,b) evaluated the recreational potential of the Bow River and the North Saskatchewan River. Block and Gummer (1979) and several other studies provide water quality monitoring results.

Two major watersheds, the Bow and North Saskatchewan, have their origins in BNP. These rivers and their tributaries are an important source of water to the prairie region. Stream erosional and depositional processes are important modifiers of landscapes in the bottoms of most mountain valleys (Baird 1977). Streams and immediate environs are important habitat for numerous wildlife and fish species in BNP (Ward 1974, Holroyd and Van Tighem 1983).

In BNP, streams are divided into four groups:

1. **small creeks**: usually first or second order streams; mean summer discharge <2 cu m/s; very numerous in BNP; *e.g.* Sunshine Creek, Louise Creek, Paradise Creek, Dolomite Creek.

2. **creeks**: usually second or third order streams; mean summer discharge of 2 to 8 cu m/s; numerous in BNP; *e.g.* Brewster Creek, Johnston Creek, Martin Creek, Fortymile Creek.

3. **small rivers**: usually third or fourth order streams; mean summer discharge of 8 to 20 cu m/s; several in BNP; *e.g.* Pipestone River, Panther River, Siffleur River, Cascade River, Clearwater River.

4. **rivers**: usually fourth or fifth order streams; mean summer discharge >20 cu m/s; rare in BNP; Bow River, Mistaya River, Howse River, North Saskatchewan River.

Portions of the Bow River and North Saskatchewan River are therefore comparatively rare features and are discussed below.

Bow River below Lake Louise: Rising near Bow Lake, the Bow River at Lake Louise has a mean July discharge of >25 cu m/s, and at Banff, approximately 100 cu m/s (Environment Canada 1974). Unlike other large BNP rivers, the Bow River below Lake Louise is mostly fed by streams that are not glacial meltwater. This results in comparatively low diurnal fluctuations and turbidity (Parks Canada 1977). The Bow River between Lake Louise and Banff is mostly a stable, pool and riffle river with a vegetated floodplain, and a single main channel (Holroyd and Van Tighem 1983). These reaches provide important habitat to numerous small mammal and bird species, particularly on water that remains open in winter. West of Banff, the river has formed a large section of meanders, truncated meanders, and overflow ponds in a bed of fine silts (Holland and Coen 1982). This landscape is dependent on stream processes and is important wildlife habitat (Holroyd and Van Tighem 1983). Beckstead (1980) discusses flooding characteristics in the area near Banff. Man's impact on the Bow River is substantial. Railway and highway construction has required manipulation of channels along several reaches of the river. Water quality has been poor in much of the river due to human fecal matter (Water Quality Branch 1985) and sewage nutrient enrichment has altered the natural fauna of the river below Lake Louise (Robinson and Smith 1974). Numerous hikers, anglers and photographers visit the river shoreline each year. In 1977, paddler use of the reach from Lake Louise to the east park boundary was over 3000 user-days. This use level exceeded that of any other river in Western Region national parks (Parks Canada 1978a).

North Saskatchewan River below the Alexandra Confluence: The North Saskatchewan River arises from the Saskatchewan Glacierand flows through BNP for more than 30 km. It is a candidate for the Canadian Heritage River System because of its natural, recreational and historical features. In summer, it is the biggest river in BNP with a mean July discharge of approximately 140 cu m/s at Saskatchewan Crossing (Environment Canada 1974). The river and its tributaries, the Howse River and the Alexandra River, have scientific value because of large areas of braided channels. Near the Alexandra confluence, two channel patterns are recognized: anastamosed or stable braided channels with vegetated banks, common in the Alexandra River, and unstable braided channels, common in the North Saskatchewan River (Smith 1973). Other significant hydrologic features along the stream include Glacier Falls (Parks Canada 1978b), and near Rampart Creek, an area of overflow ponds and meanders that are important wildlife habitat (Holroyd and Van Tighem 1983). River channels are bulldozed periodically to block erosion of the Icefields Parkway. Little development along the river has allowed the maintenance of relatively good water quality (Water Quality Branch 1985).

3.5.5 Glaciers

The Canadian Glacier Inventory (Ommanney *et al.* 1973) lists over 1000 glaciers in BNP. The majority of these are small *glacierettes* with no marked flow pattern. However, several of the larger glaciers in BNP have been studied (Water Survey of Canada 1982). Portions of four major icefields lie in BNP: Columbia Icefield, Lyell Icefield, Freshfield Icefield, and Wapta Icefield. In general, these large bodies of ice and their attendant glaciers have scientific and aesthetic value, national significance and ecological importance. The glaciers feeding the upper North Saskatchewan River have received the most comprehensive observations of any in Canada (Henoch 1971). Three of these glaciers are particularly significant.

Saskatchewan Glacier: The largest of six principal tongues of the Columbia Icefield, the Saskatchewan Glacier is the source of the North Saskatchewan River. It is a geometrically simple glacier approximately 10 km long and 1.6 km wide (Water Survey of Canada 1982). The glacier's source on Mount Snowdome is the nodal point of a three-way Continental Divide between the Atlantic, Pacific, and Arctic ocean watersheds. Studies on the glacier began in 1912 (Water Survey of Canada 1982). The toe has receded 2 to 77 m/yr. Meier (1960) used the glacier to test theories of flow patterns. Baranowski and Henoch (1978) described glacial and landform features in the area and observed that the Columbia Icefields area provides excellent examples of glacial and periglacial processes. The Saskatchewan Glacier receives skier and hiker use that has caused little or no impact.

Freshfield Glacier: This is BNP's longest glacier, running for over 10 km among the mountains near Howse Pass. It was surveyed several times between 1947 and 1954, and photographed before 1920 (Field and Heusser 1953, Water Survey of Canada 1982). In 1983, the Alpine Club of Canada built a hut in the Niverville Meadows near the glacier. Due to difficult access, the area is currently infrequently visited.

Peyto Glacier: Detailed glaciological work has been conducted for many years on the Peyto Glacier, an outlet of the Wapta Icefield about five km north of Bow Lake. The glacier was first photographed in 1896 and the first of many terminus measurements were made in 1933 (Ommanney 1972). In 1965, it was selected as a Canadian study glacier for the International Hydrological Decade (Young and Stanley 1976). Between 1945 and 1952, the glacier receded 10.7 to 77.7 m/yr. From 1965 to 1974, it had a slightly negative mass balance (accumulation minus ablation). The glacier snout responds relatively rapidly to net balance fluctuations with a lag time of probably <20 years (Leonard 1981). The glacier is seen by thousands of tourists from the Peyto Lake Viewpoint. Numerous skiers and climbers visit it due to its closeness to the Icefields Parkway and a public hut constructed on its southern edge. No environmental impacts have been documented.

3.5.6 Management Considerations

Special hydrologic resources attract and concentrate visitor use. This often results in impairment due to overuse or misuse. Water quality, soils, vegetation, wildlife and aesthetics may all be threatened. Current knowledge of hydrologic resources in BNP is inadequate because of lack of a comprehensive inventory. This affects the ability to assess the current status of the resources and to make management recommendations. A full inventory of the hydrologic resources of BNP should receive a high priority. Nevertheless, the following management considerations can be suggested to minimize impairment to special hydrologic resources.

Springs: Providing access to BNP springs has resulted in considerable damage, *e.g.* Ink Pots, Sulphur Mountain Hot Springs. Given the existing impacts, BNP should not develop any further facilities (trails and campsites) near springs, and should consider rerouting some trails (*e.g.* Panther River) to reduce future impacts near spring outlets. The development that surrounds almost all the Sulphur Mountain Hot Springs is an unfortunate circumstance. Of the eight outlets, only the Middle Springs have any remaining natural character. Special area zoning, purchasing of leased land near the springs, and rehabilitation with visitor control fences could conserve this area and its special resources from continued degradation. For other springs where continued frequent visitation is unavoidable, such as the Ink Pots, increased visitor education, construction of boardwalks, trails and restraint fences near the outlets could help contain impacts.

Waterfalls: The thousands of people that accessible waterfalls attract makes impact around waterfalls almost unavoidable. BNP has made considerable effort for public safety reasons to provide good trail systems and restraint fencing near Bow Falls and Johnston Canyon falls. Fencing could be improved to reduce plant and soil trampling. Use impacts near other significant waterfalls along the Icefields Parkway should be monitored to determine if trails and fencing are required, particularly near Panther and Bridal Veil falls. The vicinity of Martin Creek waterfalls is undisturbed. To preserve their pristine character, no trail should be constructed in this valley.

Lakes: The natural environments of many BNP lakes have special characteristics that are already impaired. Impacts include: fish stocking (all lakes except on upper Martin Creek), reduction of water quality (*e.g.* Bow Lake), trampling of lakeside vegetation and soils (especially Johnson Lake and Lake Louise), large lakeshore facilities (Chateau Lake Louise, Moraine Lake Lodge, Num-ti-jah Lodge, and Minnewanka Marina), and damming (Vermilion Lakes, Johnson Lake, and Lake Minnewanka). Recreational demands on most of these lakes continue to increase (*e.g.* angling, canoeing, windsurfing, sailing, and boating) creating other aesthetic and environmental concerns. Management actions to reduce impacts are considerable and include: restriction of motor boats to Lake Minnewanka, continued efforts to install sewage treatment facilities, removal of campsites, restrictions on camping near lakes, and trail construction to protect lakeshores from random walking. However, the high aesthetic and recreational attraction of most BNP lakes requires stricter management controls if their quality is to be preserved:

1. Additional facilities that attract visitors to lakes should be built only after detailed assessment of the effects on the lakes. This incluides new trails, picnic areas and campsites.

2. Existing facilities such as trails, picnic areas, and campsites should continue to be monitored to evaluate if improvements or relocations are necessary to reduce visitor impacts.

3. Recreational use of these lakes causes significant impacts and has resulted in historic controversy — particularly boating on Johnson Lake and Herbert Lake. Current issues include fish stocking and angling, windsurfing, and the impacts caused by swimmers and sunbathers on Johnson Lake. Park management must appreciate that many of BNP's

significant lakes cannot sustain the continued impacts of being heavily utilized for recreational purposes if natural processes and conditions are to be maintained. Further restrictions on recreational use should be considered.

Streams: Water quality in the Bow River will be substantially improved by the recent construction of the Lake Louise sewage treatment system and the planned new system at Banff. Twinning of the Trans-Canada Highway from Sunshine junction to Lake Louise must be designed to minimize channel alterations to the Bow River. Alternatives to bulldozer channelling of watercourses, such as the North Saskatchewan River near the Icefields Parkway, should be developed. Both rivers should continue to be monitored regularly for water quality and visitor use impacts. Parks Canada (1978a) describes recreational management considerations for the Bow River.

Glaciers: Human disturbance to significant glaciers is currently minimal. Water quality should be periodically monitored near huts to ensure that human wastes are properly disposed.

4. BIOLOGICAL FEATURES

4.1 Plants

Information about the plants of an area is commonly divided into *flora* and *vegetation*. The *flora* of an area is a list of the plant species that occur there. *Vegetation*, on the other hand, consists of a quantitative description of the plant communities of the area, their composition, structure, cover, biomass, etc. Sections 4.1.1 — *Rare vascular plants* and 4.1.2 — *Other significant vascular plants* deal with the flora of BNP. Section 4.1.3 — *Vegetation communities* deals with the vegetation of BNP.

Only vascular plants are considered here since, with a few exceptions, the nonvasculars (bryophytes, lichens, algae, fungi) are too poorly known to make a meaningful evaluation.

4.1.1 Rare Vascular Plants

Introduction

This list of 74 rare vascular plants was derived primarily by re-evaluating the rare species list for BNP of Achuff and Corns (1982). Also consulted were two recent works on rare vascular plants in Alberta (Argus and White 1978, Packer and Bradley 1984) and the recent *Flora of Alberta* (Packer 1983). The nomenclature and taxonomy used here generally follow Packer (1983).

Argus and White (1978) define a rare plant as "one that has a small population in the province ... restricted to a small geographical area (usually less than 3900 sq km) or it may occur sparsely over a wide area." Packer and Bradley (1984) consider a rare species to occur at usually ≤ 5 collection sites. The definition used here is essentially the same and includes plants listed by Argus and White (1978) and Packer and Bradley (1984) which occur in BNP. A *rare* plant in this report is one which has a small population as inferred from its restriction to a small geographic area (usually <500 sq km) or from having been collected at ≤ 5 localities. Individual collections from the same area are usually considered to be one locality; for example, Quartz Ridge, Eagle Mountain, Healy Creek and Mount Bourgeau are essentially one locality. In addition, these plants are often at the edge of their geographic range. All three criteria — small geographic area, ≤ 5 localities, edge of range — generally indicate a small population.

A brief account of each rare vascular plant is presented below in alphabetical order by genus and species. Information on occurrences in BNP was derived from Packer (1983) and the original maps for that flora at the University of Alberta, and from examining specimens from the following herbaria: University of Alberta (ALTA); Northern Forest Research Centre, Edmonton (CAFB); Canadian Wildlife Service, Edmonton; Banff National Park, both the naturalists' and wardens' herbaria; and collections in the author's (PLA) possession. Information on species' ranges is derived from Packer (1983), Packer and Bradley (1984), Hitchcock *et al.* (1955-1969), Hultén (1968), and Kuijt (1982), unless otherwise stated.

Some of the plants have not been reported for more than 50 years and their current existence in BNP must be questioned. Attempts were made to again find these populations during the summer of 1985, but very little time was available and only a few were found. These attempts were also hampered in most cases by vague, imprecise collection locations (*e.g.* Sawback Range, Mount Norquay). It is particularly difficult to establish the absence of a plant in an area. Consequently, these plants have been included here. Further field studies should be made to establish whether these plants are still extant in BNP or, to a higher degree of probability, that they are not. If they are now truly absent, that is itself significant for resource conservation.

Management Considerations

Virtually nothing is known of the population size, detailed areal extent or life history of any of these rare plants. The population sizes are inferred to be small relative to other plants since the rare plants occupy limited ranges. No systematic surveys have been done of likely habitats for these plants and no attempts have been made to delineate the local area occupied by known populations. No life history studies have been done and thus, only the sketchiest accounts can be made. Consequently, the only possible management measure at this time is to prevent disturbance of sites known to be occupied by these plants.

Since the ranges of these plants are so poorly known, areas which might be disturbed should be first carefully surveyed at the appropriate season for rare plants. The current absence of a collection of a rare plant from an area cannot be taken as firm evidence that the plant does not occur there, since collecting has been so unsystematic and scattered.

In summary, it is impossible with current information to assess the present status, population size trend, or impact of current or future activities on these plants.

Species Accounts

X *Agroelymus bowdenii* Boivin

X *Agroelymus bowdenii* is a grass which is a natural hybrid between *Agropyron smithii* and *Elymus innovatus*. The parental species are both common in BNP. This plant has been collected from near Lake Louise. The only other Alberta location known is near Grande Cache. It also occurs in British Columbia.

X *Agroelymus mossii* Lepage

X *Agroelymus mossii* is a grass which is a natural hybrid between *Agropyron trachycaulum* and *Elymus canadensis*. Both of the parental species occur in BNP. The type locality of this taxon is at Lake Louise and the only other known Alberta locality is at Hillsdale. The plant occurs in Montane and Lower Subalpine dry forests, a habitat also typical of the two parental species. It may be more widespread than presently known since it may not be readily recognized. The plant also occurs in British Columbia in Glacier National Park (Achuff and Dudynsky 1984b).

X *Agroelymus turneri* Lepage

X *Agroelymus turneri* is a grass and a natural hybrid between *Agropyron dasystachyum* and *Elymus innovatus*. Both parental species occur widely in BNP. It occurs in Lower Subalpine moist meadows and is known in Alberta from only two places: Lake Louise and Fort Saskatchewan (type locality). It also occurs in Saskatchewan.

Agrostis humilis Vasey

Agrostis humilis is a grass of Upper Subalpine and Alpine moist meadows. It is known from five locations in BNP: Quartz Ridge, Lost Horse Creek, Simpson Pass, Sunshine area and Healy Creek, all in the same general area. It also occurs in JNP (Mount Edith Cavell). These are the only known Alberta localities. The species also occurs in British Columbia and south in the mountains to Oregon, Utah, Nevada and Colorado.

Agrostis mertensii Trinius

Agrostis mertensii is a grass of Upper Subalpine and Alpine moist meadows and is known from three locations in BNP: Healy Creek, Castilleja Lake and Paradise Valley. It also occurs in JNP (Pyramid Mountain) and these are the only known Alberta localities. The species is circumpolar and occurs from Alaska, Yukon and the Northwest Territories, south in the Rocky Mountains to British Columbia, Utah and Colorado. It appears to be a widely, but sparsely distributed species with small local populations.

Agrostis thurberiana Hitchcock

Agrostis thurberiana is a grass of Subalpine and Alpine moist meadows. Only four locations for this species are known in Alberta; one in BNP (Simpson Pass) and three in JNP (Amethyst Lake, Centre Pass, Mount Pattison). The rest of its North American range is from Alaska and British Columbia south to California, Utah and Colorado in the mountains.

Arenaria longipedunculata Hultén (= *A. humifusa* Wahlenberg)

Arenaria longipedunculata is an herb of moist, gravelly Subalpine and Alpine sites. In Alberta, it occurs only in BNP: Spray River, Mount Aylmer, Twin Cairns, Moraine Lake road, Sunwapta Pass. In North America, it occurs from Alaska, Yukon and the Northwest Territories, south to British Columbia and Alberta. Thus, the BNP populations form the southern edge of the species' range.

Arnica longifolia D.C. Eaton

Arnica longifolia is an herb of Subalpine moist meadows and rocky slopes. In BNP, it occurs in the Sunshine - Healy Creek area. The rest of its range is south from BNP, through Highwood Pass and Waterton Lakes National Park to Colorado and from British Columbia to California. The BNP populations form the northern edge of the species' range.

Arnica parryi Gray

Arnica parryi is an herb of Lower Subalpine spruce-fir forests. It occurs widely in BNP, including Fatigue Pass, Mount Bourgeau, Lake Louise, Mistaya River and Mount Wilson. With the exception of one collection from JNP (Portal Creek), the BNP populations are at the northern edge of the species' range. The range otherwise is in Waterton Lakes National Park and south to Colorado and from British Columbia to California.

Aster xmaccallae Rydberg

Aster xmaccallae is a natural hybrid between *Aster ciliolatus* and *Aster subspicatus* which occurs in moist woods and open places in the Montane and Lower Subalpine. Both parental species are widespread in BNP. The type locality for this plant is near the Middle Springs in Banff. It has also been collected from near Lake Louise, Saskatchewan Crossing and Graveyard Flats. In Alberta, it only occurs in BNP. It also occurs in British Columbia.

Botrychium lanceolatum (Gmelin) Angstrom

Botrychium lanceolatum is a small fern of Upper Subalpine moist meadows. Of the seven locations known for this plant in Alberta, four are in BNP: near Banff, Larch Valley, and two near Bow Pass. The other collections are from the Whitegoat Wilderness Area, the Siffleur Wilderness Area (Lee *et al.* 1982) and JNP (Colonel Pass). The species is more or less circumpolar extending, in North America, from the Arctic south to Washington, Colorado, Utah, the Great Lakes and Pennsylvania.

Braya humilis (C.A. Meyer) Robinson var. *maccallae* Harris (unpubl.)

Braya humilis var. *maccallae* is a low, herbaceous cushion plant of Alpine rocky slopes. It is endemic to the Rocky Mountains of southern Alberta and British Columbia. In BNP, it is known only from the Saskatchewan Crossing area. It also occurs in JNP (Athabasca Glacier, Beauty Creek, Sunwapta River,

Morro Peak) and in Yoho National Park (Kicking Horse River near Field) which is the type locality. This variety is not validly published yet (Harris 1985) but soon should be.

Braya humilis (C.A. Meyer) Robinson var. ***porsildii*** Harris (unpubl.)

Braya humilis var. ***porsildii*** is a small, herbaceous cushion plant of Alpine scree slopes, usually derived from calcareous bedrock. In BNP, it occurs near Victoria Glacier, Mount Saskatchewan, Saskatchewan Glacier and Parker Ridge. It also occurs in JNP near the Athabasca Glacier, which is the type locality, in northeastern British Columbia and in the Mackenzie Mountains of the Northwest Territories. The variety is not validly published yet (Harris 1985) but should be soon.

Bromus altissimus Pursh (= ***B. purgans*** L.)

Bromus altissimus is a grass of Lower Subalpine forests and open areas. Of four locations in Alberta, one is in BNP near Lake Louise. It is widespread in North America, extending from British Columbia to Quebec and south to the middle of the United States.

Carex bipartita Allioni

Carex bipartita is a sedge of Upper Subalpine and Alpine moist meadows. It is known from four locations in BNP: Simpson Pass, Snow Creek Pass, Divide Creek Pass, Ptarmigan Lake. It also occurs in JNP (Signal Mountain) and Cardinal River Divide (Achuff 1984a). It is a circumpolar species extending from the Arctic south in the mountains to British Columbia, Utah and Colorado.

Carex crawei Dewey

Carex crawei is a sedge of wet, calcareous meadows mostly in the Lower Subalpine. The only BNP location is south of Saskatchewan Crossing. Other Alberta locations are at Jasper, Calgary and Fort MacLeod. It is widespread in North America extending from British Columbia to Newfoundland and south to the southern United States.

Carex deflexa Hornemann

Carex deflexa is a sedge of open Subalpine forests and meadows. It occurs in BNP at Twin Cairns, Lake Louise and Snow Creek Pass. It also occurs in JNP (Roche Bonhomme, Linda Lake). Other Alberta locations are Cypress Hills, Milk River Canyon, Glenevis, Fox Creek, Two Lakes and north of Lake Athabasca. The North American range is from Alaska to Hudson's Bay and Newfoundland south to central British Columbia, central Saskatchewan and central Manitoba and the Great Lakes. The BNP collections are near the southern limit of the species.

Carex enanderi Hultén (= ***C. eurystachya*** Hermann)

Carex enanderi is a sedge of wet Alpine meadows and lake shores. In BNP, it is known from the Sunshine area and Lake Helen near Bow Lake. The only other Alberta location is in JNP (Cavell Lake, Mount Edith Cavell). The North American range is from southern Alaska to British Columbia and Alberta. The BNP plants are at the southern edge of the species' range.

Carex glacialis Mackenzie

Carex glacialis is a sedge of Upper Subalpine and Alpine, dry meadows. In Alberta, it occurs only in BNP at Brewster Rock, Forbes Creek and Victoria Glacier. It is a circumpolar species extending from the Arctic south to Alberta, northern Saskatchewan, James Bay, northern Quebec and Newfoundland. The BNP populations form the southern edge of the species' range.

Carex illota Bailey

Carex illota is a sedge of Upper Subalpine and Alpine wet meadows. It is known from only three locations in Alberta. Two are in BNP, Simpson Pass (Scotter and Hudson 1975) and Two Jack Lake, and the other is in JNP (Tonquin Valley). It occurs in North America from southern British Columbia south to California and east to Colorado, Wyoming, Montana and Alberta. The Alberta plants are at the eastern edge of the species' range.

Castilleja hispida Bentham

Castilleja hispida is a red-flowered Indian paintbrush of Montane to Lower Subalpine dry forests and grasslands. In BNP, it is known only from Mount Norquay where it was collected in 1916. It has not been collected since, although it may have been confused with *C. miniata* and thus, overlooked. The only other Alberta collections are from Waterton Lakes National Park. In North America, it occurs from British Columbia (including Kootenay National Park) and southwestern Alberta, south to Oregon, Idaho and Montana. The BNP collection is the most northerly occurrence of the species.

Crepis atrabarba Heller

Crepis atrabarba is an herb of Montane to Lower Subalpine, dry grasslands. It occurs in BNP on the Cory Pass trail, Hillsdale, Saskatchewan Crossing and Sunset Pass. Other Alberta collections are from the Crowsnest Pass - Waterton Lakes National Park area. The North American range extends from southern British Columbia, Alberta and Saskatchewan south to Nevada and Colorado. The BNP locations are at the northern edge of the species' range.

Dicanthelium acuminatum (Swartz) Gould and Clarke (= *Panicum thermale* Boland)

Dicanthelium acuminatum is a grass of wet sites around hot springs. In Alberta, it is only known from the hot springs at Banff where it was collected in 1899 and which is the type locality. It occurs widely in North America in association with hot springs and geysers.

Draba albertina Greene

Draba albertina is a small herb of Upper Subalpine and Alpine meadows. In BNP, it has been collected at Mount Edith Pass, Rockbound Lake, Sawback Lake and Bow Pass. It also occurs in Alberta in Waterton Lakes National Park, Highwood Pass, Ram Mountain, Whitegoat Wilderness Area, Cardinal Divide, JNP and Willmore Wilderness Park (Achuff 1984a). Its range in North America is from the Yukon and Northwest Territories south in the mountains to California and Colorado.

Draba fladnizensis Wulf

Draba fladnizensis is a small herb of Alpine tundra. In BNP it is known from Divide Creek and near Lake Louise. It is known in Alberta from four other sites: Kakwa, Cardinal River Divide, Whitegoat Wilderness Area, and Ram Mountain (Achuff 1984a). The species' range is circumpolar extending from the Arctic south to northern British Columbia and Alberta. The BNP populations are at the southern edge of the range.

Draba longipes Raup

Draba longipes is an herb of Upper Subalpine and Alpine moist meadows. It occurs in BNP at Snow Creek Pass. Other Alberta location are Waterton Lakes National Park, JNP (Medicine Tent River, Portal Creek, Sassanach Mountain) and Willmore Wilderness Park (Persimmon Range). The species' range is Alaska, the Yukon and southwest Mackenzie District to British Columbia and Alberta.

Draba reptans Lamarck

Draba reptans occurs in Montane dry grasslands at only two locations in Alberta. One is in BNP on the Cory Pass trail and the other is at Fort MacLeod. These are the most northerly occurrences of this species which occurs east to Ontario and south into the southern United States.

Draba ventosa Gray

Draba ventosa is a small herb of Alpine rocky slopes. It occurs in BNP on Mount Bourgeau, near Lake Louise and near Saskatchewan Crossing. The only other Alberta locations are Highwood Pass, Whitegoat Wilderness Area (Lee *et al.* 1982) and the Opal Hills in JNP. Its North American range is from the Yukon south to Colorado and Utah.

Drosera linearis Goldie

Drosera linearis is a sundew which occurs in peatlands. Only four locations are known in Alberta for this species: Lake Louise, Rocky Mountain House, Edson and south of Lake Athabasca. The Lake Louise collection was by John Macoun in 1904 and it has not been reported from BNP since. It occurs across North America from British Columbia to Newfoundland and south to the northern United States.

Epilobium luteum Pursh

Epilobium luteum is an herb of Lower Subalpine moist forest and streambanks. Four localities are known for Alberta: two in BNP (near Banff and Bow Pass) and two in JNP (Lynx Creek and near Jasper). The North American range is from Alaska to northern California, British Columbia and Alberta. The BNP plants are at the southeastern extremity of the species' range.

Epilobium saximontanum Haussknecht

Epilobium saximontanum is an herb of Subalpine and Alpine moist meadows and stream banks. It occurs in BNP near Banff and on Storm Mountain. Other Alberta localities are at Ram Falls, Ram Mountain, Mountain Park, JNP (Miette River, Pyramid Mountain), near Lesser Slave Lake and in the Crowsnest Pass area. It also occurs in Kootenay National Park (Tumbling Creek), Glacier National Park (Mountain Creek) and Mount Revelstoke National Park (Skunk Cabbage trail) (Achuff and Dudynsky 1984a,b). The species' range is from Alberta and British Columbia to eastern Oregon, California, Arizona and New Mexico with a disjunct portion from Hudson's Bay to Newfoundland.

Erigeron purpuratus Greene ssp. *pallens* (Cronquist) G. Douglas (= *E. pallens* Cronquist)

Erigeron purpuratus is an herb of Upper Subalpine and Alpine rocky slopes. It occurs in BNP at Marvel Pass, Eagle Mountain, Citadel Mountain, Quartz Ridge, Parker Ridge and Mount Athabasca. It also occurs at Crowsnest Pass, Highwood Pass and JNP (Shovel Pass). In North America, it occurs from Alaska, the Yukon and Northwest Territories to southern Alberta and British Columbia.

Eriophorum callitrix Chamisso

Eriophorum callitrix is a cottongrass of Upper Subalpine and Alpine peatlands. In BNP, it has been collected only from Snow Creek Pass. It is known in Alberta also from JNP (Kidney Lake, Whistler's Mountain), Cardinal River Divide and Whitegoat Wilderness Area (Lee *et al.* 1982). It occurs in North America from the Arctic south to British Columbia, Alberta, Ontario, Quebec and Newfoundland. A disjunct population occurs in Wyoming.

Erysimum pallasii (Pursh) Fernald

Erysimum pallasii is an herb of Alpine scree slopes. In BNP, it occurs at Healy Creek, Redoubt Mountain, Whitehorn Mountain, Lake Louise and Mount Coleman. Other collections in Alberta are from the Whitegoat Wilderness Area (Lee *et al.* 1982) and JNP (Whistler's Mountain, Opal Hills, Bald Hills, Goat Mountain). This plant occurs in North America from the Arctic south to the southern Northwest Territories and is disjunct to Alberta. The BNP populations are at the southern edge of the disjunct species range.

Habenaria unalascensis (Sprengel) Watson

Habenaria unalascensis is an orchid which grows in Montane wet woods and meadows. In BNP, it occurs in the Middle Springs Swamp at Banff, near Lake Louise and near Mount Coleman. Other locations in Alberta are in JNP (Honeymoon Lake) and in the Waterton Lakes National Park - Crowsnest Pass area. It is widespread in North America, from southeastern Alaska to California, Nevada, Utah, Colorado, South Dakota, the Great Lakes area and eastern Quebec.

Haplopappus uniflorus (Hooker) Torrey & Gray

Haplopappus uniflorus is an herb of Montane and Lower Subalpine wet meadows and river banks. In BNP, it occurs at Barrier cabin on the Panther River and is otherwise restricted to the northern end of the park: Saskatchewan Crossing, Howse River, Alexandra River, and Graveyard Flats. Elsewhere in Alberta, it has been collected at Police Outpost Provincial Park near the United States border, east of the BNP boundary along the North Saskatchewan River to Kootenay Plains, in JNP (Mud Lake), near Grande Prairie and in Wood Buffalo National Park. Its North American range is restricted to Alberta and the southern part of the District of Mackenzie.

Hieracium cynoglossoides Arv.-Touv. (= *H. albertinum* Farr)

Hieracium cynoglossoides is an herb of Montane to Lower Subalpine open forests and meadows. In BNP, it occurs at Lake Minnewanka, Stoney Squaw Mountain, Healy Creek, Mount Bourgeau, Johnston Creek, Castle Mountain and Paradise Valley. Other collections in Alberta are from the Porcupine Hills, Crowsnest Pass and Waterton Lakes National Park. The range of the species is from Alberta and British Columbia south to Oregon, Utah and Wyoming. The BNP populations are thus at the northern extreme of the species' range.

Juncus biglumis L.

Juncus biglumis is a rush which grows in Upper Subalpine and Alpine wet meadows. It occurs in BNP at Twin Cairns, Boom Mountain, Lake Agnes and Sunwapta Pass. Other Alberta locations are in Kananaskis Provincial Park (Lawson Lake) and JNP (Whistler's Mountain, Mount Edith Cavell). It is a circumpolar species extending from the Arctic to Wyoming, Colorado, Hudson's Bay and northern Quebec.

Juncus parryi Engelmann

Juncus parryi is a rush of moist Subalpine meadows. It occurs in BNP at Mount Bourgeau and, in the Lake Louise area, at Redoubt Mountain and Lake Agnes. Other Alberta collections are from the Whitegoat Wilderness Area (Lee *et al.* 1982), Kananaskis Provincial Park, Highwood Pass and Waterton Lakes National Park. The North American range is from Alberta and British Columbia to California and Colorado. The BNP populations are at the northern boundary of the species' range.

Listera caurina Piper

Listera caurina is an orchid of Lower Subalpine moist forests. Only four collections have been made in Alberta; one in BNP (Spray River), one on the Carbondale River and two in Waterton Lakes National Park. Otherwise the species occurs from southeastern Alaska to northern California, western Montana, Alberta and Wyoming.

Lithophragma glabrum Nuttall (= *L. bulbifera* Rydberg)

Lithophragma glabrum is an herb of Montane dry grasslands and open forests. Only one collection is known for BNP: Johnston Creek in the Bow Valley. Other Alberta occurrences are from Crowsnest Pass to Waterton Lakes National Park and also in the Cypress Hills. The total species' range is from British Columbia and Alberta south to California, Nevada, Utah, Colorado, South Dakota and southwestern Saskatchewan. The BNP collection is thus at the northern edge of the range.

Lithophragma parviflorum (Hooker) Torrey & Gray

Lithophragma parviflorum is an herb of Montane dry grasslands. It occurs in BNP at Stoney Squaw Mountain, Mount Norquay and Johnston Creek. Other Alberta collections are further south, from Kootenay Pass to Waterton Lakes National Park. The species' range is from British Columbia and Alberta south to California, Nevada, Utah, Wyoming and South Dakota. The BNP populations are at the northern extremity of the species' range.

Melica spectabilis Scribner

Melica spectabilis is a grass of Subalpine meadows. In BNP, it occurs in the Sunshine area and on Castle Mountain. The only other Alberta locations are on the Carbondale River and in Waterton Lakes National Park. The species' range is from southern British Columbia south to California and east to Alberta, Montana, Wyoming and Colorado. The BNP plants are at the northern edge of the species' range.

Mitella breweri Gray

Mitella breweri is an herb of Upper Subalpine moist forests. In BNP, it occurs at Marvel Pass, in the Sunshine area, Simpson Pass and Lake Agnes. Other Alberta locations are in Kananaskis Provincial Park (Lawson Lake), Kootenay and North Kootenay passes and in Waterton Lakes National Park. The species' range is from British Columbia and Alberta south to California, northern Idaho and western Montana. The BNP populations form the northern edge of the species range.

Osmorhiza chilensis Hooker & Arnold

Osmorhiza chilensis is an herb of Subalpine moist forests. Collections in BNP are from Redearth Creek,

Boom Creek, Mount Murchison and Howse River. Other Alberta collections are from Cypress Hills, Waterton Lakes National Park, JNP and the Kakwa Falls area. In North America, the species extends from southern Alaska to California, Arizona, Colorado and South Dakota, and east to the Great Lakes and Newfoundland.

Pedicularis racemosa Douglas

Pedicularis racemosa is an herb of Subalpine meadows. In BNP, it occurs at Marvel Lake and near Lake Louise. The only other Alberta collections are from JNP (Palisades, Maligne Lake). The species' range is from British Columbia and Alberta, south to California and New Mexico.

Pellaea atropurpurea (L.) Link

Pellaea atropurpurea is a small fern of Montane calcareous cliffs. Collections in BNP are from Tunnel Mountain and Mount Rundle. Other Alberta collections are from Canmore, Kananaskis (Wasootch Creek) and JNP. The distribution of this species in North America is spotty with occurrences from southern British Columbia and Alberta to New Mexico and Arizona, in northern Saskatchewan, and from eastern Ontario to Florida and Texas.

Pellaea glabella Mett. var. *occidentalis* (Nelson) Butters

Pellaea glabella is a small fern of Montane dry limestone cliffs. In BNP, it occurs at Tunnel Mountain, Mount Cory, Mount Norquay, and in the Sawback Range. It also occurs in Alberta in Kananaskis Provincial Park, northwest of Calgary, Kootenay Plains, JNP (around Jasper) and Entrance. The North American range is widespread but spotty from the western Northwest Territories and British Columbia east to Quebec and south to Washington, Utah, Arizona and Tennessee.

Penstemon fruticosus (Pursh) Greene var. *scouleri* (Lindley) Cronquist

Penstemon fruticosus is an herb of Subalpine dry rocky slopes. It occurs in BNP in the Spray River valley and at Fatigue Pass. Other Alberta collections are from JNP (Mount Edith Cavell), Kananaskis Provincial Park, Highwood Pass and the Crowsnest Pass area. The North American range is from southern British Columbia and Alberta to Oregon, Montana and Wyoming.

Poa lettermanii Vasey

Poa lettermanii is a grass of Upper Subalpine and Alpine meadows. In BNP, it occurs on Citadel Mountain, Mount Bourgeau and Mount Brett. The only other Alberta collections are from JNP (Whistler's Mountain, Bald Hills). The species' range is from British Columbia and Alberta to California, Nevada, Utah and Colorado.

Poa stenantha Trinius

Poa stenantha is a grass of Subalpine open forests. Two of three Alberta locations are in BNP: Bourgeau Lake and Lake Agnes. The third locality is in Waterton Lakes National Park. The species occurs in Asia and in North America from Alaska and the Yukon to Oregon, Idaho, Montana and Colorado.

Polygonum austiniae Greene

Polygonum austiniae is an herb of Subalpine open areas. In BNP, it occurs near Lake Louise and the Panther River. The only other Alberta locality is in Waterton Lakes National Park. The species' range is from southeastern British Columbia and Alberta to California, southern Idaho, southcentral Montana and Wyoming. It is also a rare species in British Columbia and occurs in Glacier National Park (Achuff and Dudynsky 1984b). The BNP populations are at the northern limit of the species' range.

Pteridium aquilinum (L.) Kuhn

Pteridium aquilinum (bracken fern) is a large fern of Montane and Lower Subalpine moist forests. Only one collection has been made of this species in BNP; it was near the hot springs in Banff in 1899. Since it has not been reported for more than 85 years, despite a rather intensive study of the area (Marsh 1974), it may not be currently extant in BNP. Other Alberta locations are in JNP (Short Creek) and in the Crowsnest - Waterton Lakes National Park area. It is a cosmopolitan species which in North America has a bicentric distribution pattern. The western portion is from southern Alaska to California, east to Alberta and west Texas, and south to Central America. The eastern range is from southern Manitoba to Newfoundland and south to the Gulf states. The BNP plants, if they still exist, are thus along the eastern edge of the western portion of the range in North America.

Ranunculus grayi Britton (= *R. gelidus* Karel. & Kiril. ssp. *grayi* (Britton) Hultén)

Ranunculus grayi is an buttercup of Subalpine to Alpine dry slopes. In BNP, it occurs at Hillsdale and Redoubt Mountain. Other Alberta collections are from Ram Mountain, JNP (Wilcox Pass, Opal Hills, Bald Hills, Whistler's Mountain) and Copton Lookout. The North American range is from Alaska, the Yukon and northwestern District of Mackenzie to British Columbia, Alberta, Montana and Colorado.

Ranunculus occidentalis Nuttall

Ranunculus occidentalis is a buttercup of moist Alpine meadows. It occurs in BNP at Snow Creek Pass. Other Alberta locations are in the Whitegoat Wilderness Area (Lee *et al.* 1982), JNP (from the Whirlpool River to the north boundary along the Continental Divide) and Willmore Wilderness Park. The species' range is from Alaska, the Yukon and northwest Mackenzie District to California, British Columbia and Alberta.

Ranunculus verecundus B.L. Robinson

Ranunculus verecundus is a buttercup of Upper Subalpine and Alpine moist meadows. All Alberta collections but two are from BNP: Bryant Creek, Healy Creek, Sawback Range, Lake Agnes, Arnica Lake, Bow Pass and Mount Wilson. The other locations are the Whitegoat Wilderness Area (Lee *et al.* 1982) and near Torrens Lookout, northwest of Grande Cache. The species' range is from British Columbia and Alberta to Oregon, Idaho and Montana.

Rhododendron lapponicum (L.) Wahlenberg

Rhododendron lapponicum is a dwarf shrub of Alpine moist slopes. It occurs in BNP on Mount Coleman above Sunset Pass (Hrapko 1985). Other Alberta locations are the Bighorn Mountains, Ram Mountain, Shunda Mountain, Nordegg, JNP (Southesk River) and Cardinal River Divide (Achuff 1984a).

Ribes laxiflorum Pursh

Ribes laxiflorum is a shrubby currant of Lower Subalpine moist forests. In BNP, it occurs at Lake

Louise and Chephren Lake. Other Alberta locations are in JNP (upper Athabasca River, Geraldine Lake trail, Tonquin Valley, Roche DeSmet). The species' range is from southern Alaska and the Yukon to California, northern Idaho and Alberta. The BNP populations are at the southern edge of the range.

Rorripa tenerrima Greene (= *R. obtusata* (Nuttall) Britton)

Rorripa tenerrima is a small herb of Subalpine moist open areas. It occurs at Owl Lake in BNP. The only other Alberta locations are at Fort MacLeod and Calgary. The species' range is from British Columbia and Alberta to California, Utah, New Mexico, Nebraska and Missouri. The BNP population is at the northeast edge of the species' range.

Rumex pauciflorus Nuttall

Rumex pauciflorus is an herb of Subalpine moist meadows. In BNP, it occurs in the Sunshine area and the Bare Range near the Panther River. Other Alberta localities are JNP (Maligne River) and Willmore Wilderness Park. The species' range is from British Columbia and Alberta to California and Colorado.

Salix boothii Dorn (= *S. pseudocordata* (Andersson) Rydberg)

Salix boothii is a shrubby willow or small tree of Montane and Subalpine moist meadows and streamsides. It occurs in BNP near Banff (Cave and Basin, Vermilion Lakes) and Scotch Camp. Other Alberta locations are Waterton Lakes National Park, Crowsnest Pass, Cypress Hills, Calgary and Fort Saskatchewan. The species range is southern British Columbia and Alberta to northern California and Colorado.

Salix lanata L. ssp. *calcicola* (Fernald & Weigand) Hultén

Salix lanata is a willow shrub of Lower Subalpine moist river floodplains. In BNP, it has been collected only from Graveyard Flats where the Alexandra River joins the North Saskatchewan River. The only other Alberta location is in JNP (Whirlpool River). The species is circumpolar occurring in North America from Alaska, the Yukon and northern Baffin Island to northern British Columbia, northern Manitoba, Quebec and Newfoundland with disjunct occurrences in Alberta and Gaspé. The BNP location is thus a disjunct population at the southern extreme of the species' range.

Saxifraga flagellaris Willdenow

Saxifraga flagellaris is an herb of calcareous, turfy Alpine tundra. It occurs in BNP at Quartz Ridge (Porsild 1959), Healy Creek and Indianhead Creek. Other Alberta locations are at Ram Mountain, Hummingbird Creek, Whitegoat Wilderness Area, Cardinal River Divide, JNP (Roche DeSmet), Willmore Wilderness Park and Kakwa (Achuff 1984a). The species' range includes Asia, Alaska, the Yukon, and Northwest Territories south to British Columbia and Alberta. The BNP populations are at the southern edge of the species' range.

Saxifraga nelsoniana D. Don

Saxifraga nelsoniana is an herb of Upper Subalpine and Alpine moist meadows, ledges and banks. The only BNP collection is from the Lake Louise area. Other Alberta locations are in the Whitegoat Wilderness Area (Lee *et al.* 1982), JNP and Torrens Lookout, north of JNP. The species' range includes Asia and, in North America, Alaska and the Northwest Territories to Oregon, British Columbia and Alberta. The BNP population is at the southern edge of the species' range.

Saxifraga nivalis L.

Saxifraga nivalis is an herb of Upper Subalpine and Alpine meadows. It is recorded only from Sentinel Pass in BNP. Other Alberta collections are from Kananaskis Provincial Park, Ghost River Wilderness Area, Whitegoat Wilderness Area, JNP (Wilcox Pass, Whistler's Mountain), Cardinal River Divide, Willmore Wilderness Park, and Kakwa (Achuff 1984a). The species is circumpolar and extends in North America from the Arctic south to British Columbia, Alberta, the Mackenzie District, Hudson's Bay and the Ungava Peninsula. The BNP locality is near the southern extreme of the species' range.

Sorbus sitchensis Roemer

Sorbus sitchensis (mountain ash) is a shrub of Subalpine moist forests. In BNP, it occurs at Vermilion Pass, Lake Louise and Mount Patterson. It also occurs in JNP (Lynx Creek, Blue Creek, Smoky River) and from Crowsnest Pass to Waterton Lakes National Park. The North American range is from southern Alaska to California and east to Alberta and northwestern Montana.

Sparganium hyperboreum Laestadius

Sparganium hyperboreum is an aquatic herb of Upper Subalpine and Alpine lakes. The only BNP collection is from Simpson Pass. The only other Alberta collections are from JNP (Lick Creek, Tonquin Valley). It is a circumpolar species ranging in North America from Alaska, the Yukon, and northern British Columbia to Alberta, Manitoba, Hudson's Bay, Labrador and Newfoundland. The BNP population is disjunct and at the southern edge of the species' range.

Stellaria umbellata Turczaninov

Stellaria umbellata is an herb of Subalpine meadows and open forests. In BNP, it occurs at Healy Creek, Taylor Lake and Snow Creek Pass. The only other Alberta collection is from Waterton Lakes National Park. The species occurs in Eurasia and, in North America, from Alaska, British Columbia and Alberta to California, Colorado and Montana.

Thuja plicata D. Don

Thuja plicata (western red cedar) is a tree of Subalpine moist forests. It occurs in northern BNP, usually as a shrub or small tree (1-5 m tall), at Glacier Lake, Survey Peak and the Castleguard River. Other Alberta occurrences are in JNP (Twintree Lake), Kananaskis and Crowsnest Pass. The species' range is Alaska to California and northwest Montana. This species is a common forest dominant in British Columbia and barely extends in Alberta. The BNP collections are at the eastern edge of the species' range.

Tsuga heterophylla (Rafinesque) Sargent

Tsuga heterophylla (western hemlock) is a tree of Subalpine moist forests, although the plants found in BNP to date have all been <2 m tall. It occurs in northern BNP at Mount Coleman (52° 04'N, 116° 56'W), Alexandra River (52° 05'N, 116° 59'W) and Castleguard River (52° 02'N, 117° 08'W). The only other Alberta collections are from JNP (Whirlpool River, Fryatt Creek). The species' range is from southern Alaska to northern California and northwestern Montana. The BNP plants are at the eastern edge of the species' range. The species was unknown in Alberta until collected in 1976-1978 during the BNP-JNP ecological land classification (Achuff and Corns 1985). It is also rare in Kootenay National Park (Achuff and Dudynsky 1984a) where it occurs near Vermilion Crossing. It occurs in Yoho National Park (Kuchar 1978) and is a common, major species in Mount Revelstoke and Glacier National Parks (Achuff and Dudynsky 1985b).

Vaccinium ovalifolium J.E. Smith

Vaccinium ovalifolium (huckleberry) is a shrub of Lower Subalpine moist forests. It occurs in northern BNP at Chephren Lake, Glacier Lake, Southeast Lyell Glacier and Arctomys Creek. All other Alberta locations are in JNP along the west side of the park from Lick Creek to Short Creek (Achuff and Corns 1985). The species' range includes eastern Asia and, in North America, from southern Alaska and British Columbia to Oregon, Montana and Alberta, with disjunct occurrences in the Great Lakes area and from southern Quebec to Newfoundland and Nova Scotia. The BNP plants are at the eastern edge of the main species' range in western North America.

Veronica catenata Pennell (= *V. salina* Schur and *V. anagallis-aquatica* L.)

Veronica catenata (water speedwell) is an aquatic herb of wet stream sides. The only collection from BNP is from near the Cascade Power House. Other Alberta collections are at Fish Creek Provincial Park, Okotoks, Fort MacLeod and Irvine. The species occurs in Eurasia and in North America from British Columbia to southern Quebec and south to California, New Mexico, Nebraska, Oklahoma, Missouri, Ohio and Pennsylvania.

Viola glabella Nuttall

Viola glabella is a yellow-flowered violet of Montane and Subalpine moist forests. In BNP, it occurs near Banff and on the Rockbound Lake trail. Other Alberta collections are from Waterton Lakes National Park, Crowsnest Pass and North Kootenay Mountain. The species' range is southern Alaska, British Columbia and Alberta to California and Montana.

Woodsia glabella R. Brown

Woodsia glabella (smooth woodsia) is a small fern of Lower Subalpine moist calcareous cliffs and rocks. In BNP it is known only from the Sawback Range. Other Alberta collections are from Kananaskis Provincial Park, JNP (Medicine Lake) and Entrance. It is a circumpolar species occurring in North America from the Arctic south to British Columbia, northern Saskatchewan, central Manitoba, Lake Superior, New York, Labrador and Newfoundland.

4.1.2 Other Significant Vascular Plants

Range Boundary Species

Many vascular plants reach the edge of their range in BNP. Some of these species are *rare* and are described above in section 4.1.1. The more common ones are dealt with here.

Populations at the edge of their range in BNP are significant for two main reasons. First, they provide excellent opportunities for scientific research on the factors that determine geographic ranges. The question of what factors control the range of an organism is important both theoretically and practically. The essentially undisturbed ecosystems of BNP provide an ideal opportunity to study natural populations in their natural habitats. Secondly, such populations are ideal for monitoring. Being at the edge of their range, and close to environmental tolerance limits, such populations are thought to be quite sensitive to environmental changes.

Since the eastern boundary of BNP is close to the eastern edge of the Rocky Mountains, numerous species which are restricted to mountain habitats have an eastern limit which corresponds essentially to the eastern limit of mountain habitat and the eastern boundary of BNP. Such range boundaries are not considered to be significant here. The range boundaries which are considered significant are northern or southern limits where, at least grossly, seemingly suitable habitat extends north or south along the mountains. For example, *Larix lyallii* (subalpine larch) has a northern range limit along a line from about Bow Pass to Clearwater Pass and the Red Deer River. Large areas of seemingly suitable Upper Subalpine habitat occur north of this limit, although the tree does not.

Information on ranges was derived primarily from Packer (1983). Other sources include: Achuff (1984a), Hitchcock *et al.* (1955-1969), Hultén (1968) and Kuijt (1982). This range information must not be regarded as final; additional collections will likely extend some known ranges and define other range boundaries more precisely. However, this list will flag these species as of special interest and may encourage scientists to study them. The location of range boundaries has been generalized as:

> *southern BNP*: south of a line through Vermilion Pass, Castle Mountain, Flints Park, Panther Mountain and the Dormer River at the east boundary of BNP.
>
> *central BNP*: north of the above limit to a line through Bow Pass, Mount Kentigern and along the north boundary of BNP to the head of Indianhead Creek.
>
> *northern BNP*: north of the northern limit for central BNP to the JNP boundary.

These three areas have no known biological significance and were chosen primarily because they could be recognized on current, small-scale distribution maps.

The following list of 41 plants with a range boundary in BNP is in alphabetical order by genus and species.

Anemone richardsonii: southern boundary in southern BNP.
Astragalus bourgovii: northern boundary in northern BNP.
Berberis repens: northern boundary in southern BNP.
Besseya wyomingense: northern boundary in southern BNP.
Calamagrostis rubescens: northern boundary in central BNP.
Campanula lasiocarpa: southern boundary in southern BNP.
Cardamine bellidifolia: southern boundary in southern BNP.
Cardamine umbellata: southern boundary in southern BNP.
Carex franklinii: southern boundary in central BNP.
Carex haydeniana: northern boundary in central BNP.
Carex platylepis: northern boundary in central BNP.
Carex simulata: northern boundary in northern BNP.
Danthonia parryi: northern boundary in central BNP.
Delphinium nuttallianum: northern boundary in central BNP.
Erigeron x arthurii: northern boundary in central BNP.
Erigeron trifidus: southern boundary in southern BNP.
Eriogonum ovalifolium: northern boundary in central BNP.
Eriogonum umbellatum: northern boundary in central BNP.
Gentiana glauca: southern boundary in central BNP.
Hackelia jessicae: northern boundary in northern BNP.
Haplopappus lyallii: northern boundary in central BNP.
Hedysarum sulphurescens: northern boundary in northern BNP.
Heuchera cylindrica: northern boundary in central BNP.
Juncus stygius: southern boundary in central BNP.
Juniperus scopulorum: northern boundary in southern BNP.
Larix lyallii: northern boundary in central BNP.
Ledum glandulosum: northern boundary in southern BNP.
Lupinus sericeus: northern boundary in northern BNP.
Luzula arcuata: southern boundary in central BNP.
Lycopodium alpinum: southern boundary in southern BNP.
Pedicularis capitata: southern boundary in central BNP.
Pedicularis contorta: northern boundary in central BNP.
Pinus flexilis: northern boundary in northern BNP.
Poa leptocoma: southern boundary in southern BNP.
Primula mistassinica: southern boundary in southern BNP.
Puccinellia distans: southern boundary in southern BNP.
Pyrola grandiflora: southern boundary in southern BNP.
Scirpus pumilis: southern boundary in southern BNP.
Senecio pseudaureus: northern boundary in central BNP.
Sitanion hystrix: northern boundary in central BNP.
Townsendia parryi: northern boundary in central BNP.

Oldest Douglas Fir in Alberta

The oldest Douglas fir (*Pseudotsuga menziesii*) tree known in Alberta (Alberta Forestry Association 1984) is in BNP near Johnson Lake (51°11'42"N, 115°29'32"W). The tree is currently about 682 years old and is still growing (Jozsa *et al.* 1984). It occurs above the Cascade River hoodoos in an open stand with other Douglas firs which are more than 500 years old. The dry site has contributed to the longevity of these trees by reducing the likelihood of fungal diseases and by reducing fuel accumulation thus preventing intense fires. The tree is 83.8 cm in diameter at breast height and 13.7 m tall (Jozsa *et al.* 1984).

This tree and the stand in which it grows are of great scientific value. The reconstruction of past climates with tree ring data requires old trees, growing in a climatically sensitive site and a lengthy record of climatic data from instruments. This site is one of the few in Canada with trees this old. The growth ring patterns show a sensitivity to climatic variation and the climatic records from Banff townsite, which are continuous since 1887, are both one of the longest records of temperature and precipitation in western Canada and highly relevant to the site. Thus, this stand of old Douglas firs is one of the best sites for paleoclimatic studies in Canada (Jozsa *et al.* 1984).

The location of this stand of very old trees should be made well known to parks staff so that inadvertent damage does not occur.

4.1.3 Vegetation Communities

The vegetation classification used here is from the ecological land classification of Banff and Jasper National Parks (Achuff and Corns 1982) in which 77 *vegetation types* were recognized in BNP. Vegetation classification is not applied as uniformly as is species classification. Workers use a variety of systems and scales. The Banff-Jasper ecological land classification vegetation system has been subsequently used and extended to other portions of the Rocky Mountains in both British Columbia (Achuff and Dudynsky 1984a,b) and Alberta (Achuff 1984a, 1985, Lee *et al.* 1982). The classification system has been applied to most of the Rocky Mountains in Canada and the northern United States, either directly or indirectly by examining other studies (*e.g.* British Columbia - Lea 1984, Utzig *et al.* 1983, Montana - Pfister *et al.* 1977). This provides a context for evaluation of vegetation communities larger than just BNP and JNP.

Two criteria were used to select vegetation types as special features:

1. small areal extent.

2. restriction to a particular portion of BNP.

It is not possible to calculate the area of each vegetation type from the ecological land classification data for two reasons. First, no vegetation type map was made. The units (Ecosites) mapped during the ecological land classification were defined by a combination of several environmental components and often contain more than one vegetation type. Secondly, the vegetation sampling was geared to an ecological land classification mapping objective and was not designed to estimate the area or abundance of individual vegetation types. Nevertheless, there is often a rough correlation between the areal extent of a vegetation type and the number of sample plots for that vegetation type or the areal extent of the Ecosites of which it is a component. These two approximate indications, number of plots of the vegetation type in BNP and the area of the Ecosites in which the vegetation type occurs, were used to select significant vegetation types. In addition, many of the vegetation types selected by the above criteria occur only in the Montane Ecoregion in BNP, which is the smallest and most highly impacted Ecoregion in the park, and which reinforces the initial selection of the significant vegetation types.

Vegetation types that occupy a small area in BNP include:

Montane grasslands - H6, H7, H13, H19

Montane dry forest - C1, O5, O2

aspen forests - C16

loess deposition forests - C26

The following vegetation types are restricted to a particular portion of BNP:

Front Ranges - C33, O19

Northern BNP - C12, O11

Southern BNP - C9, C23

These 15 significant vegetation types and their occurrence in BNP are described below. More complete descriptions are in Achuff and Corns (1982).

Montane Grasslands

The Montane Ecoregion occupies about 2% of BNP, the smallest area of any Ecoregion in the park. It occurs below an elevation of about 1650 m, in the Bow Valley from Johnston Creek to the east gate and along the North Saskatchewan River and the Howse River from Glacier Lake east to the park boundary. The Montane Ecoregion is the warmest and driest Ecoregion and contains several vegetation types which both occupy a small area and are restricted to the Montane Ecoregion.

The majority of the landscape of BNP is covered by forest, and grasslands are restricted to a few specialized habitats, usually where localized microclimates are warmer and drier. The four grassland vegetation types described below are all restricted to such sites in the Montane Ecoregion. The dry microclimate of these sites is undoubtedly very influential in maintaining the grassland vegetation rather than forest. However, in some tracts, particularly in the Bow Valley, trees appear to be encroaching on the grassland and, in the absence of fire, will gradually reduce the amount of grassland in the Montane Ecoregion. Re-establishment of a more natural fire regime would help maintain these grasslands.

H6: ***Koeleria cristata - Artemisia frigida - Linum lewisii***

(junegrass - pasture sage - wild blue flax)

The H6 vegetation type is dominated by junegrass (*Koeleria cristata*) with pasture sage (*Artemisia frigida*), wild blue flax (*Linum lewisii*), everlasting (*Antennaria nitida*) and gaillardia (*Gaillardia aristata*) also important. Unvegetated bare soil is common. It occupies dry, level to moderately sloping sites on fluvial, morainal and eolian landforms. It occurs primarily on tracts of the HD4 and NY3 Ecosites in the Bow Valley from Hillsdale to Lake Minnewanka and the east gate. Small patches also occur around Saskatchewan Crossing, mostly on tracts of NY3.

Besides the role of fire, as noted above, active deposition of eolian loess may be an important factor in maintaining H6, especially in the Saskatchewan Crossing area. H6 also occurs in JNP (Achuff and Corns 1982) and on the Ya Ha Tinda ranch (Achuff 1978).

H7: ***Agropyron dasystachyum - Artemisia frigida***

(wheatgrass - pasture sage)

The H7 vegetation type is characterized by a dominance of wheatgrass (*Agropyron dasystachyum*), pasture sage (*Artemisia frigida*), junegrass (*Koeleria cristata*) and yarrow (*Achillea millefolium*). Unvegetated mineral soil is commonly up to 50% of the ground surface. H7 usually occurs on dry, steeply sloping, south-facing sites on a variety of landforms. In BNP, it occurs mostly on tracts of the NY3 Ecosite in the Bow Valley from Hillsdale to Lake Minnewanka. It also occurs in JNP (Achuff and Corns 1982).

H13: ***Stipa richardsonii - Koeleria cristata - Antennaria lanata***

(Richardson needlegrass - junegrass - everlasting)

The H13 vegetation type is dominated by Richardson needlegrass (*Stipa richardsonii*) with junegrass (*Koeleria cristata*) less prominent. Other characteristic species include everlasting (*Antennaria nitida*), cut-leaf anemone (*Anemone multifida*), little clubmoss (*Selaginella densa*) and, in BNP, rough fescue (*Festuca scabrella*). It occupies dry, south aspects in the Bow Valley from Mount Norquay to the Cascade River, especially in the vicinity of the golf course, and is most common on tracts of the HD2, HD4 and NY3 Ecosites. H13 is often associated with H6. H13 also occurs in JNP (Achuff and Corns

1982).

H19: ***Agropyron spicatum - Elymus innovatus- Aster conspicuus***

(bluebunch wheatgrass - hairy wild rye - showy aster)

The H19 vegetation type is characterized by the dominance of bluebunch wheatgrass (*Agropyron spicatum*) and hairy wild rye (*Elymus innovatus*). It occurs on dry, southwest aspects in small patches as unmappable inclusions in the NY1 and GA1 Ecosites in the vicinity of Hillsdale in the Bow Valley. It may occur elsewhere in the Bow Valley in places not yet recognized because of its small patch size. H19 has an affinity with other bluebunch wheatgrass dominated vegetation types in southwestern Alberta, southeastern British Columbia, Idaho and Montana (Mueggler and Stewart 1980).

Montane Dry Forest

Forests dominated by Douglas fir and limber pine are characteristic of the Montane Ecoregion. These three vegetation types (C1, O5, O2) occur only in the Montane Ecoregion and occupy small, restricted areas. They are also of scientific interest because these two tree species are at or near their northern range limits in BNP.

C1: ***Pseudotsuga menziesii/ Elymus innovatus***

(Douglas fir/hairy wild rye)

Douglas fir is the dominant canopy tree in the C1 vegetation type, with white spruce (*Picea glauca*) and lodgepole pine (*Pinus contorta*) also often present. Juniper (*Juniperus communis*), buffaloberry (*Shepherdia canadensis*) and prickly rose (*Rosa acicularis*) are dominant shrubs, and hairy wild rye (*Elymus innovatus*) and pinegrass (*Calamagrostis rubescens*) dominate the herb-dwarf shrub layer. It occurs on dry, south-facing slopes in the Bow Valley from Johnston Creek to the east gate, along Lake Minnewanka and along the North Saskatchewan River near Saskatchewan Crossing, typically in tracts of the NY1, NY3 and PT3 Ecosites. Many of the stands are 200 to 300 years old or more. The older, larger trees have a thick, fire-resistant bark and many contain several fire scars indicating that fires were common in the past.

C1 also occurs in JNP and in Kootenay National Park and Yoho National Park in British Columbia (Achuff and Dudynsky 1984a, Kuchar 1978) as well as southern Alberta and British Columbia, and into the northern United States (Achuff and Corns 1982).

O5: ***Pseudotsuga menziesii/ Juniperus communis/ Arctostaphylos uva-ursi***

(Douglas fir/juniper/bearberry)

The O5 vegetation type is an open forest dominated by Douglas fir with an understory composed mainly of juniper (*Juniperus communis*) and bearberry (*Arctostaphylos uva-ursi*). It is restricted to dry, south and west aspects in the Bow Valley from Hillsdale to the east gate and near Lake Minnewanka, mostly on steeply sloping tracts of the NY3 Ecosite. These sites are drier than those of C1.

Trees in O5 stands are often 300 years old or more and the oldest Douglas fir in Alberta (682 years) occurs in an O5 stand near Johnson Lake (section 4.1.2).

O5 does not occur in JNP, although it does occur in Kootenay National Park and Yoho National Park (Achuff and Dudynsky 1984a, Kuchar 1978) and also in southern British Columbia (Achuff and Corns 1982).

O2: ***Pinus flexilis-Pseudotsuga menziesii/ Juniperus*** **spp.** ***/ Arctostaphylos uva-ursi***

(limber pine-Douglas fir/juniper/bearberry)

The O2 vegetation type is characterized by the presence of limber pine (*Pinus flexilis*) in an open forest. Douglas fir (*Pseudotsuga menziesii*) is also often present and the understory is dominated by junipers (*Juniperus communis* and *Juniperus scopulorum*) and bearberry (*Arctostaphylos uva-ursi*). O2 occurs on dry, steeply sloping, south-facing erosional scarps along the lower Bow Valley and North Saskatchewan River in the Montane Ecoregion, mostly in tracts of the NY3 Ecosite. It occupies both a very small and

restricted area of BNP.

Limber pine reaches its northern limit in North America in the Saskatchewan Crossing area O2 stands. Similar stands occur in the Kootenay Plains area, east of Saskatchewan Crossing and along the Red Deer River, between the park boundary and the Ya Ha Tinda ranch (Achuff 1984b). Comparable vegetation types are known from Waterton Lakes National Park and the Porcupine Hills in southern Alberta, from Yoho National Park and Montana (Achuff and Corns 1982).

Aspen Forests

C16: ***Populus tremuloides/ Elymus innovatus-Lathyrus ochroleucus***

(aspen/hairy wild rye-peavine)

Aspen (***Populus tremuloides***) dominates the C16 vegetation type. The understory often contains shrubs of buffaloberry (***Shepherdia canadensis***), prickly rose (***Rosa acicularis***) and juniper (***Juniperus communis***) and the herb-dwarf shrub layer is dominated by the grasses hairy wild rye (***Elymus innovatus***) and pinegrass (***Calamagrostis rubescens***). The area occupied by aspen forests in BNP is small and restricted mainly to south-facing, fluvial landforms mostly in the Montane Ecoregion of the Bow River and North Saskatchewan River valleys on tracts of the HD1 and GA1 Ecosites. Some stands occur in lower part of the Lower Subalpine in tracts of the PP2 and PT4 Ecosites.

Loess Deposition Forests

Loess is a fine, silty material deposited by wind. Loess deposition sites as a surficial geological feature are discussed above in section 3.2.2. These sites are occupied, in part, by a closed forest vegetation type (C26) which is restricted to these loess deposition areas.

C26: ***Picea glauca/ Shepherdia canadensis/ Thuidium abietinum***

(white spruce/buffaloberry/fern moss)

White spruce (***Picea glauca***) dominates the closed tree layer and buffaloberry (***Shepherdia canadensis***) dominates the shrub layer in the C26 vegetation type. However, it is the dominance of fern moss (***Thuidium abietinum***) in the bryoid layer which differentiates C26 from other similar vegetation types. C26 occurs primarily in the Saskatchewan Crossing area of BNP on tracts of the HD3 and TA3 Ecosites along the Howse River and North Saskatchewan River, where loess is being actively deposited. Small areas of C26 forest are also known from the lower Red Deer River and Clearwater River where broad river flats provide a source of the loess. The loess deposition areas at Devil's Gap and near the Banff airfield are not known to have C26 forest.

C26 also occurs in the Athabasca Valley in JNP (Achuff and Corns 1982) but is not known from anywhere else currently.

Vegetation Types Restricted to the Front Ranges

Two vegetation types (C33, O19) are restricted to the Front Ranges in BNP. The causes of this restriction are not known although mesoclimatic differences are probably influential. Several other features in BNP show a Main Ranges - Front Ranges dichotomy including species ranges, Subalpine permafrost (section 3.4.1) and climate (Janz and Storr 1977).

C33: ***Picea engelmannii/ Elymus innovatus***

(Engelmann spruce/hairy wild rye)

The dominance of Engelmann spruce (***Picea engelmannii***) in the tree layer and of hairy wild rye (***Elymus innovatus***) in the herb-dwarf shrub layer characterize C33. It usually occurs on steep, south-facing slopes in the Upper Subalpine, mostly in tracts of the WF4 Ecosite, but also occasionally in EG1, MQ1, PP3 and TR1 tracts. In BNP, C33 is known from the watersheds of the Cascade River, Panther River, Red Deer River, Clearwater River and Siffleur River, including Harrison Lake, Douglas Lake, McConnell Creek, Martin Creek and Dolomite Creek. C33 also occurs in a small part of the Front Ranges in JNP (Achuff and Corns 1982), but it is known nowhere else.

O19: ***Picea engelmannii-Abies lasiocarpa/ Dryas octopetala***

(Engelmann spruce-subalpine fir/mountain avens)

O19 is an open forest dominated by Engelmann spruce (*Picea engelmannii*) in the tree layer and by mountain avens (*Dryas octopetala*) in the herb-dwarf shrub layer. It occurs at the upper altitudinal limit of the Upper Subalpine, forming the treeline, on steep slopes in tracts of the BP1, SF1, TR2, WF3 and WH1 Ecosites. In BNP, it is known from the upper Panther River, Dormer River, Pipestone River and Clearwater River and from Silverhorn Creek. It also occurs in JNP and elsewhere in the Canadian Rockies (Achuff and Corns 1982).

Vegetation Types Restricted to Northern BNP

Two vegetation types (C12, O11) are largely restricted in BNP to north of Bow Pass. Both have been found south of there only occasionally in BNP.

C12: ***Picea engelmannii-Pinus albicaulis/ Menziesia glabella***

(Engelmann spruce-whitebark pine/false azalea)

The codominance of Engelmann spruce (*Picea engelmannii*) and whitebark pine (*Pinus albicaulis*) in a closed forest is distinctive for C12. The shrub layer is dominated by false azalea (*Menziesia glabella*). C12 occurs on steep slopes in both the Lower and Upper Subalpine, mostly in the Main Ranges north of Saskatchewan Crossing, although two small areas of C12 are known from Boom Lake and Mystic Lake. C12 is more common in JNP and similar whitebark pine forests also are known from Yoho National Park, southwestern Alberta and the northern United States (Achuff and Corns 1982).

O11: ***Picea*** **spp.*/ Ledum groenlandicum/Tomenthypnum nitens***

(spruce/Labrador tea/brown moss)

O11 is an open forest dominated usually by black spruce (*Picea mariana*) with a shrub layer of Labrador tea (*Ledum groenlandicum*) and a well developed moss layer of brown moss (*Tomenthypnum nitens* and *Aulacomnium palustre*). It occurs in wet, poorly drained sites in tracts of the BK1, BK4, BK6, CA1, CV1, MC1, HC1, PT5 and VL1 Ecosites in the Montane and Lower Subalpine Ecoregions. In BNP, O11 is known mostly from the Mistaya River and North Saskatchewan River valleys. A few stands occur in southern BNP in the lower Cascade River and Bow River valleys where white spruce (*Picea glauca*) is the dominant tree, since black spruce does not occur in BNP south of Bow Pass.

O11 occurs commonly in JNP and similar vegetation types are known from Kananaskis and north into the Northwest Territories (Achuff and Corns 1982).

Vegetation Types Restricted to Southern BNP

C9: ***Pinus contorta/Vaccinium caespitosum***

(lodgepole pine/dwarf bilberry)

C9 is characterized by the dominance of lodgepole pine (*Pinus contorta*) in the tree layer and dwarf bilberry (*Vaccinium caespitosum*) in the herb-dwarf shrub layer. It occurs on level benchlands along the Bow River from Lake Louise to the east gate and along the Spray River on Montane and Lower Subalpine tracts of the AL1, FR1 and SP1 Ecosites. C9 also occurs in Kootenay National Park (Achuff and Dudynsky 1984a) as well as east of BNP along the Red Deer River and in Montana (Achuff and Corns 1982).

C23: ***Larix lyallii-Abies lasiocarpa/Vaccinium scoparium-Antennaria lanata***

(subalpine larch-subalpine fir/grouseberry-everlasting)

C23 is characterized by the dominance of subalpine larch (*Larix lyallii*) in the tree layer. It occurs in the Upper Subalpine, often forming the treeline, in BNP south of a line from Hector Lake to the Panther River. A few subalpine larch trees occur north of this line to Clearwater Pass and Snow Creek Pass (Achuff 1978) but they are too few to form the C23 vegetation type.

C23 also occurs in Kootenay National Park (Achuff and Dudynsky 1984a), Yoho National Park and south into Montana and the Pacific Northwest of the United States (Achuff and Corns 1982).

4.2 Animals

4.2.1 Invertebrates

Several invertebrates that occur in BNP are known from few if any other locations in Alberta. In some cases, these species are not found elsewhere. Their restricted ranges may be partly an artifact of being inconspicuous and not of interest to many collectors.

Physa johnsoni

The snail *Physa johnsoni* is endemic to five springs and their outflow streams near Sulphur Mountain (Clarke 1981). It was first found in the Upper Hot Springs in 1927 and is also known from Kidney Spring, Middle Springs (the type locality), Cave and Basin Spring, Vermilion Lakes Spring, and a warm stream near the Banff Springs Hotel (Clarke 1973). It is an endangered species (Clarke 1976) which is vulnerable because of its restricted distribution and is threatened by development of the springs in which it occurs. Proposed developments affecting hot springs on Sulphur Mountain should be carefully evaluated for impact on this rare species.

Argia vivida

Argia vivida is a damsel fly which occurs in warm springs on Sulphur Mountain (Pritchard 1971, Walker 1927). It occurs from Mexico to southern Canada (Pritchard 1980) and is known from only two locations in Canada other than the BNP sites. One is at Field, British Columbia in Yoho National Park and the other in Glacier National Park, British Columbia (Walker 1953). Thus, the BNP populations are at the northern edge of the species' range. In other portions of its range, it occurs in cold springs and the occurrence in warm springs at the northern edge of its range in BNP has been of scientific interest (Pritchard and Pelchat 1977, Pritchard 1980).

Artemiopsis stefanssoni

Artemiopsis stefanssoni is a fairy shrimp which occurs mainly in the Canadian Arctic and Greenland but also has a highly disjunct occurrence in a small pond in the Alpine Ecoregion at Dolomite Pass (Hartland-Rowe and Anderson 1968). This is the furthest south the species is known and it may have been dispersed there by migrating waterfowl (Hartland-Rowe and Anderson 1968).

Salmasellus steganothrix

Salmasellus steganothrix is an isopod which is known from only four locations. Three are in Alberta — Castleguard Cave, a cave near Cadomin and Horseshoe Lake in JNP (Clifford and Bergstrom 1976); the fourth, highly disjunct location is in southern Washington (Holsinger *et al.* 1983). This animal was the first troglobite (obligate cave dweller) known in Canada (Bowman 1975). It is blind and unpigmented, and is the only species in its genus. It occurs throughout most of Castleguard Cave.

The species is considered rare due to its small population size and very limited distribution. The present policy of restricting access to Castleguard Cave should be continued to protect these animals.

Stygobromus canadensis

Stygobromus canadensis, an amphipod, is endemic to a series of pools about two km inside Castleguard Cave (Holsinger *et al.* 1983). It is extremely rare, being known from only five specimens.

The cave faunas of the Northern Hemisphere have been extensively studied in the last several decades and, with very few exceptions, the troglobites are restricted to unglaciated areas. Some have continuous distributions on both sides of glacial boundaries and likely migrated into glaciated areas after glacial retreat. Only six species, including *Salmasellus steganothrix* and *Stygobromus canadensis*, are endemic to or have isolated, disjunct populations in glaciated areas (Holsinger *et al.* 1983). These species appear to have survived the Pleistocene glaciation in subglacial refugia, including Castleguard Cave, and their present distribution reflects preglacial distributions (Holsinger *et al.* 1983, Pugsley 1983). Castleguard Cave is known from other evidence to have been intact and ice-free for more than 720,000 years

(Pugsley 1983).

Stygobromus canadensis is rare and perhaps endangered since it is known from only this one location. Present restrictions on access and collecting permits should be continued to protect this species.

4.2.2 Fish

The fish discussed here are rare either in BNP or nationally (COSEWIC 1985), have a restricted distribution in BNP, or are threatened or endangered. Four species of game fish are native to BNP: Westslope Cutthroat Trout (*Salvelinus clarki lewisi*), Bull Trout (*Salvelinus confluentis*), Mountain Whitefish (*Prosopium williamsoni*), and Lake Trout (*Salvelinus namaycush*). Of these, the Westslope Cutthroat Trout and the Bull Trout are threatened and becoming, if not already, rare (Butler and Maw 1985). Introduced fish in BNP include: Yellowstone Cutthroat Trout (*Salvelinus clarkei bouvieri*), Rainbow Trout (*Salmo gairdneri*), Brown Trout (*Salmo trutta*), Brook Trout (*Salvelinus fontinalis*), and Cisco (*Coregonus artedii*)

In addition to the larger game fish, a number of smaller species both native and introduced occur in BNP. An endemic subspecies, the Banff Longnose Dace (*Rhinichthys cataractae smithi*), is endangered, of scientific value and possibly extinct. Also of interest are three species of tropical fish which have been introduced to the Cave and Basin Hotsprings (Nelson 1983).

Westslope Cutthroat Trout (*Salvelinus clarki lewisi*)

The Westslope subspecies of Cutthroat Trout is native to BNP and originally occurred widely in the mountains and foothills of southern Alberta (Behnke 1979). However, extensive stocking programs since 1921 (Perren 1982) have resulted in hybridization of many native cutthroat populations with the Yellowstone Cutthroat and with Yellowstone - Rainbow Trout hybrids (McAllister*et al.* 1981). Another effect of stocking non-native species has been the competitive replacement of native fish by Brown Trout and Brook Trout (McAllister *et al.* 1981).

The Cutthroat Trout of ten lakes in the Bow River system were examined in 1980 (McAllister *et al.* 1981) by both morphological and electrophoretic isozyme analysis. Although the native Westslope Cutthroat Trout has been extirpated throughout much of its range in western Canada, genetically pure populations were found in eight of the ten lakes: upper Block Lake, Elk Lake, Fish Lakes (3), Marvel Lake, lower Twin Lakes and Mystic Lake. Taylor Lake, which was stocked in 1931, contained pure Yellowstone Cutthroats. Baker Lake contained hybrids which are morphologically Westslope Cutthroats but the isozyme analysis shows 91% Westslope isozymes and 9% Yellowstone isozymes. Hybridization with Rainbow Trout has been noted in Waterfowl Lake which was stocked with Rainbow Trout in 1934 and with cutthroats in 1936 (Ward 1974).

Consequently, native cutthroat populations, which are part of the original, native fauna of BNP and which are additionally desirable because the genetic diversity of native stocks is adapted to unique, local environmental conditions (McAllister *et al.* 1981), are restricted to a small part of their former range and are in danger of being extirpated by genetic introgression with Yellowstone Cutthroat Trout and by competition from other exotic species.

Bull Trout (*Salvelinus confluentis*)

Until recently, the Dolly Varden Trout was considered to occur from the Pacific coast to the eastern slopes of the Rocky Mountains in Alberta. However, more recent work has shown that the fish in the interior of British Columbia and in Alberta is a distinct species, the Bull Trout (*Salvelinus confluentis*), which differs from the Dolly Varden (*Salvelinus malma*) of coastal streams in Alaska, British Columbia and Washington (Butler and Maw 1985).

The Bull Trout is widespread in the Rocky Mountain National Parks but numbers have declined significantly in recent years and it should be regarded as a threatened species which will soon be rare in BNP, if it is not rare already. A recent stream survey in BNP found no Bull Trout (Butler and Maw 1985). Bull Trout have not been stocked in the park.

Banff Longnose Dace (*Rhinichthys cataractae smithii*)

The Banff Longnose Dace (*Rhinichthys cataractae smithii*) was described as a subspecies in 1916 (Nichols 1916) and is endemic to the Cave and Basin Hotsprings drainage. The status of this fish was

recently evaluated because of changes in both taxonomic concepts and the environment of the Cave and Basin Hotsprings. The evaluation concluded that the Banff Longnose Dace is a valid taxonomic subspecies but that by 1981 it had become virtually extinct (Renaud and McAllister 1985). It had been recommended for designation as an endangered subspecies (Lanteigne 1981).

Between 1915 and 1971, the Banff Longnose Dace apparently hybridized with the Eastern Longnose Dace (*Rhinichthys cataractae cataractae*) which occurs naturally in the Bow River. Collections from 1892 to 1981 indicate a gradual decline of the Banff Longnose Dace. Factors contributing to the extinction include the introduction of tropical fish to the hotspring (see below) and alterations in both the quantity and quality of hotspring flow (Renaud and McAllister 1985). The introduced species, especially the tropical fish, may have affected the Banff Longnose Dace by competition for food, predation, aggressive territoriality or the introduction of diseases or parasites. Changes in water quality (dissolved oxygen content, pollutants) or quantity (lowered water levels and temperatures) also may have negatively affected the Banff Longnose Dace (Renaud and McAllister 1985). It is virtually impossible to determine, after the fact, which factors caused the decline but it is known that a temporary diversion of spring flow coincided with the disappearance of two species of introduced fish in the hotsprings (Nelson 1983). Current operational guidelines for the Cave and Basin Pool should maintain satisfactory levels of water quantity and quality in the hotspring drainage in the future.

The Banff Longnose Dace appears, practically, to be extinct. However, since no comprehensive search has been made of other BNP locations, there is a very slight possibility that other populations exist (McAllister 1986). Further sampling of springs and streams in the Bow Valley should be done. In any case, the Banff Longnose Dace is perhaps of greatest value as an example of the damage that can be done to park resources through lack of adequate information and lack of adequate assessment of impacts from environmental manipulation. Many park resources are more poorly known than the Banff Longnose Dace and their present occurrence is perhaps more fortuitous than due to knowledgeable management. The extinction also indicates that non-native species should not be introduced to the park.

Introduced Tropical Fish

Currently, three species of introduced tropical fish occur in the Cave and Basin Hotsprings drainage (Nelson 1983). Mosquitofish (*Gambusia affinis*) was introduced to these waters in 1924 for mosquito control. The other two species, Sailfin Molly (*Poecillia latipinna*) and Jewelfish (*Hemichromis bimaculatus*), were introduced apparently by aquarists by at least 1960. Six other species of tropical fish were introduced during the 1960's but have failed to survive: Guppy (*Poecillia reticulata*), Green Swordtail (*Xiphophorus helleri*), Convict Cichlid (*Cichlasoma nigrofasciatum*), Angelfish (*Pterophyllum scalare*), Blue Gourami (*Trichogaster trichopterus*), Siamese Fighting Fish (*Betta splendens*).

The occurrence of these non-native species in a national park is incongruous with Parks Canada policy. However, removal of these fish from the Cave and Basin is complicated by the existence of other rare native species such as the snail *Physa johnsoni* and, possibly, the Banff Longnose Dace. An evaluation of current management policies for the Cave and Basin should be made to deal with recreational use, introduced species and rare native species.

4.2.3 Amphibians and Reptiles

The species discussed here are either rare or uncommon and near a range boundary (Holroyd and Van Tighem 1983).

Spotted Frog (*Rana pretiosa*)

The spotted frog occurs from southeast Alaska through British Columbia to western Alberta (Wright and Wright 1949) and BNP is near the eastern edge of its range. It is uncommon in BNP (Holroyd and Van Tighem 1983) and the least common ranid frog in Alberta, known from only about 20 locations in the province (Alberta Fish and Wildlife 1984). Most reports in BNP are from Vermilion Lakes. Other observations are from Anthracite, the Spray River, Altrude Creek, Baker Creek, Pipestone River, upper Bow River, Mistaya River, North Saskatchewan River and Alexandra River. Spotted frogs spawn in small ponds and river terraces up to about 2000 m elevation. Nearly two-thirds of the reports are from the Lower Subalpine Ecoregion, about one-third from the Montane and the remainder from the Upper Subalpine (Holroyd and Van Tighem 1983). At Vermilion Lakes, it occurs near the warm sulphur spring which flows into the Third Lake (Bow Valley Naturalists 1978). Records of this species go back to 1914 when N.B. Sanson collected some from the recreation grounds and Cave and Basin Marsh

(Holroyd and Van Tighem 1983).

Pollution and habitat disturbance are of management concern. Runoff containing salts from highway salting operations may affect spotted frogs in BNP. High salt concentrations may retard spring emergence of adults and larval development (Morris and Tanner 1969). Consequently, highway salting should be minimized in areas adjacent to spotted frog habitat such as McNair Pond, Herbert Lake and between Norman Creek and Rampart Creek. Some ponds by the Icefields Parkway along the Mistaya River have been drained eliminating spawning sites.

Long-toed Salamander (*Ambystoma macrodactylum*)

The Long-toed salamander occurs from southern British Columbia and Vancouver Island to the Rocky Mountains in Alberta. It is one of only two species of salamander in Alberta and is rare both in the province and in BNP (Alberta Fish and Wildlife 1984, Holroyd and Van Tighem 1983). In BNP, it is known from only 11 breeding sites, all in the Bow Valley south of Castle Junction (Holroyd and Van Tighem 1983), including: small ponds north of the Trans-Canada Highway from east gate to the Minnewanka interchange, the golf course ponds, Vermilion Lakes, Healy Creek backswamp, several temporary ponds along the Bow Valley Parkway and a small pond near Altrude Creek at Castle Junction (Achuff 1978, Holroyd and Gartshore 1978). It occurs most commonly in small ponds with muddy bottoms and grassy margins close to forests in fluvial wetlands of the Montane Ecoregion.

The earliest record of this species is from 1896 in Banff townsite. It is probably less numerous now than previously since the larvae are eaten by trout stocked in ponds and lakes. Pilot Pond was formerly called Lizard Lake because of the large number of salamanders present until stocked trout eliminated them (Holroyd and Van Tighem 1983). The present policy of stocking fish only in lakes containing natural populations of fish should prevent further damage of this type to the species.

Wandering Garter Snake (*Thamnophis elegans vagrans*)

The wandering garter snake occurs from coastal British Columbia, through southern and central Alberta to western Saskatchewan (Behler and King 1979). It is the only snake known to occur in BNP and is rare in the park. The red-sided garter snake (*Thamnophis sictalis parietalis*) may occur in BNP but it has not been confirmed (Holroyd and Van Tighem 1983). Most reports of this species in BNP are from the Cave and Basin area where there is a hibernaculum, although its exact location is not known. Other sightings are from near the Fenland Trail and at Ghost Lakes (Holroyd and Van Tighem 1983). It is restricted in BNP to the Montane Ecoregion in the Bow Valley where it finds a suitable combination of food, climate and denning habitat.

The hibernaculum and the area around the Cave and Basin should receive special attention to protect this highly critical habitat. The dependence of this species on such limited habitat makes it extremely vulnerable in BNP.

4.2.4 Birds

The species considered here include both *rare* resident (summer, winter or year-round) and migrant species and *uncommon* species which have a *restricted distribution* in the park. *Rare* includes the *rare* and *very rare* categories of Holroyd and Van Tighem (1983). Rare visitors are not considered here because their occurrence is unpredictable and impractical to manage for. As well, four Bird Communities which are of limited areal extent in BNP, and one species of scientific interest are discussed.

The information below is from Holroyd and Van Tighem (1983) and Warden Wildlife Files (1945-1976, 1977-1985) unless otherwise cited. The National Audubon Society periodically compiles a *Blue List* of species which are undergoing a noncyclic population decline or range contraction, either local or widespread (Tate and Tate 1982). Such species are not *endangered* yet but the adverse trend in population or range is cause for management concern. The occurrence of these species in BNP is noted. The order of species follows Holroyd and Van Tighem (1983) for ease of reference, although a more recent checklist order is now available (AOU 1983).

Several rare species nest in cavities in dead trees, *e.g.* Wood Duck, Hawk Owl, Lewis' Woodpecker. Park activities which might affect these dead trees, such as firewood cutting, fire management or insect and disease control, should be evaluated for their impact on cavity-nesting birds.

Rare Resident Species

This section includes rare summer or year-round residents known or suspected to breed in BNP.

American Bittern (*Botaurus lentiginosus*)

The American Bittern is a rare summer resident in BNP. It occurs regularly only at Vermilion Lakes, although there are single sightings from the middle Bow River , Mistaya River and North Saskatchewan River. It is most common in Bird Community 9 which is associated with Montane shrub wetland. The American Bittern is a Blue List species and has been seen only once (May 1981 at Vermilion Lakes) in the last four years.

Wood Duck (*Aix sponsa*)

The Wood Duck is rare in Alberta as well as in BNP. It is known to have bred in only two places in Alberta, one of which is on Fortymile Creek. Between 1975 and 1984, there are 15 records (Davidson 1985a, Warden Wildlife Files 1945-1976, Warden Wildlife Files 1977-1985), with most sightings at Vermilion Lakes, Fortymile Creek, near the horse stable marsh and Johnson Lake. Wood Ducks occur on slowly moving streams, backwaters, beaver ponds and marshes with partially wooded margins in the Montane and Lower Subalpine Ecoregions.

Goshawk (*Accipiter gentilis*)

The Goshawk occurs throughout southern Canada and is a rare resident in BNP. It is part of Bird Community 4 which occurs mainly in Montane and Lower Subalpine dry, spruce-pine open forest. Since 1976, Goshawks have been recorded 31 times and one nest was found near Shadow Lake (Davidson 1985b). Sightings are most common (87%) in the Front Ranges (Fig. 2).

Goshawks are a highly prized hunting bird in many countries today (Beebe 1974), and thus a potential for poaching in the park exists.

Cooper's Hawk (*Accipiter cooperi*)

Cooper's Hawk is a rare resident in BNP. It once bred throughout most of North America, but is now absent from three-quarters of Canada. It suffered a major decline in the eastern part of its range between 1958 and 1965 probably due to DDT. Cooper's Hawk is a Blue List species and is rare in Canada (COSEWIC 1985). Since 1975 it has been recorded 12 times in BNP, seven from the Front Ranges (Fig. 2).

Cooper's Hawk is a definitive species of Bird Community 1 and reaches its maximum densities in this community which occurs typically in Montane poplar forests. The species also occurs in forested parts of the Lower Subalpine Ecoregion, especially around fluvial fans.

Bald Eagle (*Haliaeetus leucocephalus*)

The Bald Eagle is a rare resident of BNP which breeds locally throughout North America. In BNP, it occurs around shrub wetlands and lakes in the Montane and Lower Subalpine Ecoregions, particularly the VL Ecosection. The only known nest site in BNP is at Vermilion Lakes. This nest has been active from 1973 to 1985, except in 1980 and 1984. Other pairs have nested recently outside the park at Exshaw and east of Saskatchewan Crossing. Sightings in the lower Bow Valley from 1976 to 1984 are in Fig. 3.

Merlin (*Falco columbarius*)

The Merlin is a rare summer resident of BNP which occurs throughout North America and Eurasia. Before 1981, only four sightings were reported in the park. From 1981 to 1984, there have been 12 reports, four of a pair of birds. Ten of the 12 sightings were in 1984. The observations are from many parts of BNP. Merlins migrate through BNP in both spring and fall.

Hawk Owl (*Surnia ulula*)

Fig. 2. Accipiter observations in Banff National Park, 1975-1984.

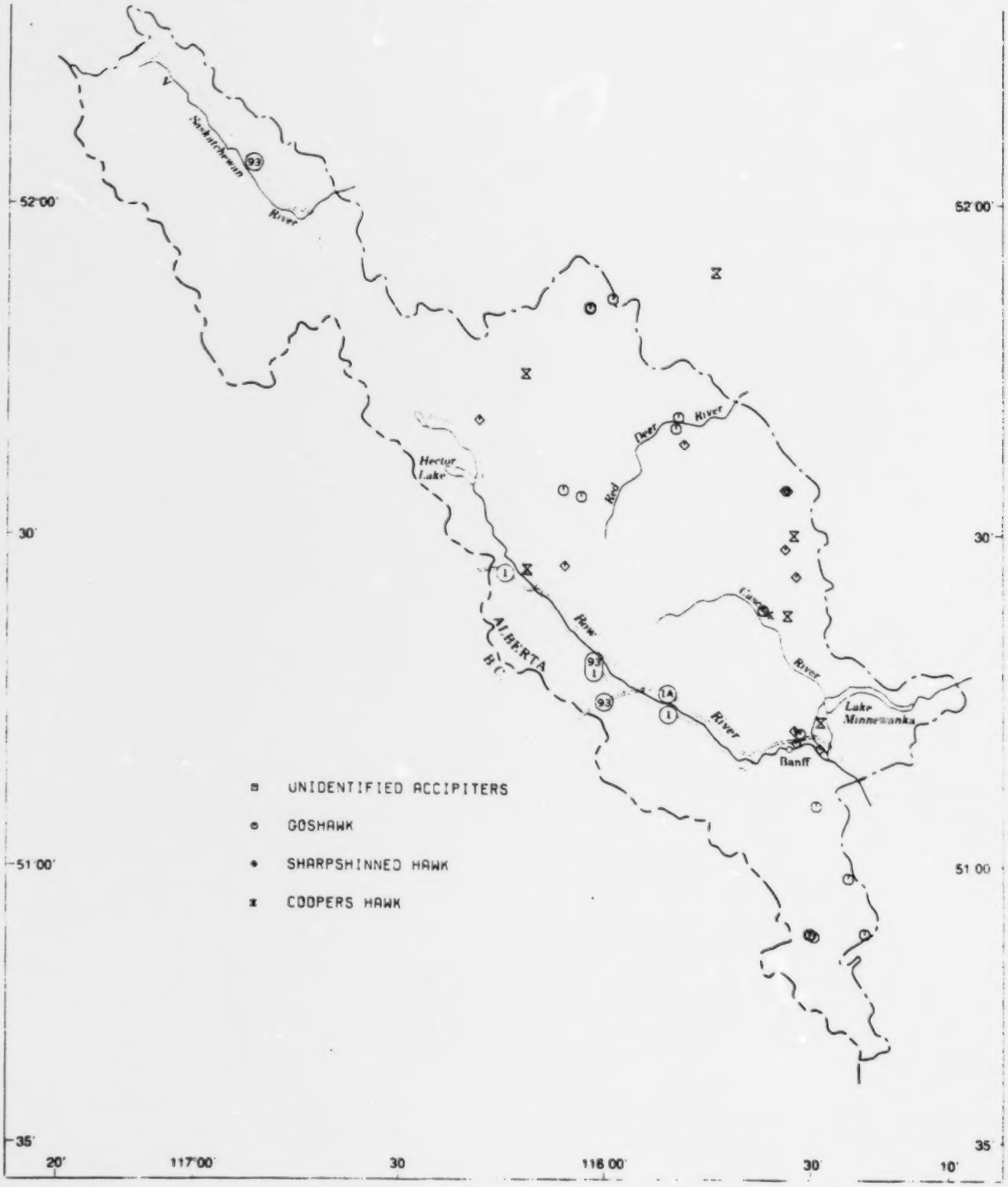
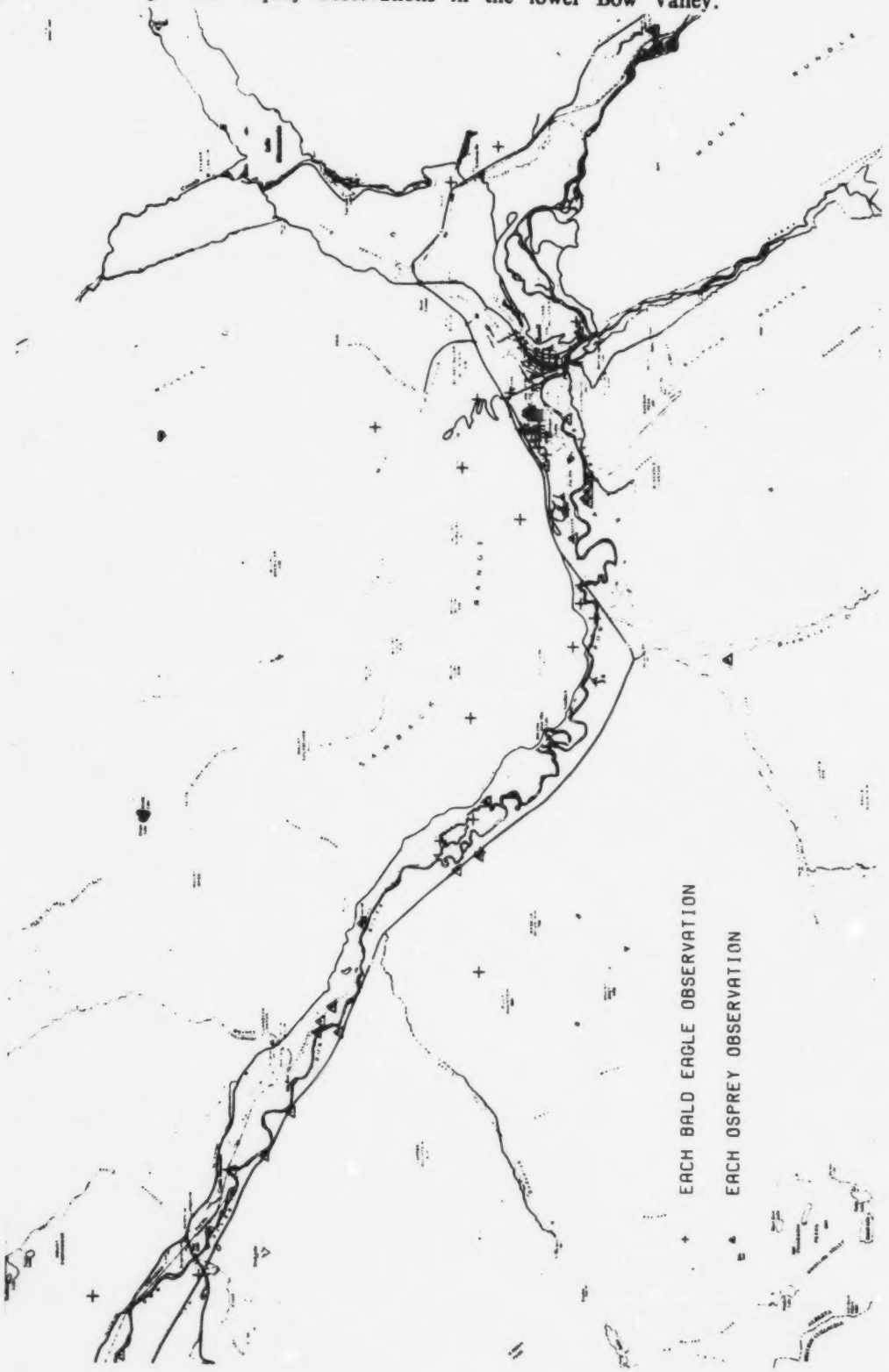


Fig. 3. Bald Eagle and Osprey observations in the lower Bow Valley.



The Hawk Owl is a rare resident in BNP which breeds locally in the mountains and northern half of Alberta. Most observations of this species have been from the Bow Valley and around Lake Louise. Fledged young were observed in the summers of 1975 to 1979 in the Vermilion Pass burn where they had nested in pockets of unburned spruce-fir forest inside the recent burn. The most recent sighting was in July 1982 in the middle Bow Valley. They also have been seen in Montane wetland forest and Subalpine spruce-fir forest.

Barred Owl (*Strix varia*)

The Barred Owl is a rare resident in BNP although it has not been observed in the winter. It has been recorded twice near Saskatchewan Crossing, twice near Vermilion Lakes and once at Tunnel Mountain. It prefers mature riparian forest of white spruce and balsam poplar in the Montane Ecoregion.

Great Gray Owl (*Strix nebulosa*)

The Great Gray Owl is a rare resident of BNP, although no nests have been found. It occurs throughout northern Alberta, where it is rare (COSEWIC 1985), and is known to nest in JNP, Kootenay National Park and east of BNP (Holroyd and Van Tighem 1983, Salt and Salt 1967). Since 1975, it has been reported mostly from the Bow Valley (7 sightings), with single reports from Baker Creek and the lower Red Deer River. It prefers coniferous and mixed coniferous-deciduous forests near wetlands and meadows in the Montane and Lower Subalpine Ecoregions.

Long-eared Owl (*Asio otus*)

The Long-eared Owl is a rare summer resident in BNP, which occurs throughout central and southern Alberta (Salt and Salt 1976). Only four records are known from BNP since 1975, all from the Bow Valley — Vermilion Lakes, Muleshoe and Hillsdale. A nest was found at Muleshoe. It is a member of Bird Community 1 which typically occurs in poplar forests and dense willow shrublands on fluvial wetlands and fans of the Montane Ecoregion.

Black Swift (*Cypseloides niger*)

The Black Swift breeds throughout western North America (Godfrey 1966) and occurs locally in the Rocky Mountains of Alberta. Only two nesting colonies are known in Alberta (Salt and Salt 1976), one at Johnston Canyon in BNP and the other at Maligne Canyon in JNP. Although fairly common in BNP, as a breeding bird it must be considered rare in the park. The number of active nests in Johnston Canyon is 5 to 10 usually (Holroyd 1985). It nests in crevices and holes of cliffs near waterfalls where each pair raises one young/year.

Calliope Hummingbird (*Stellula calliope*)

The Calliope Hummingbird is a rare resident of BNP which breeds in the Rocky Mountains from Waterton to Jasper, although no nests have been found in BNP. It occurs mostly in open areas (avalanche slopes, burns, meadows, open forests) where flowers are abundant from the Montane to the Upper Subalpine. It is a dominant species in Bird Community 13 which is associated with Montane grasslands.

Lewis' Woodpecker (*Asyndesmus lewis*)

Lewis' Woodpecker is a rare summer resident in BNP which occurs from southwestern Alberta and southern British Columbia to New Mexico and California (Salt and Salt 1976). It nests uncommonly in the mountains of Alberta from JNP to Waterton Lakes National Park. Only five records are known from BNP; one from Vermilion Pass and four from the lower Bow Valley. It nests in dead snags and seems to prefer dry, open forests in the Montane and old burns.

Black-backed Woodpecker (*Picoides arcticus*)

The Black-backed Woodpecker is a rare resident in BNP. It occurs throughout the mountains and northern half of Alberta but is nowhere common (Salt and Salt 1976). Although no nests or young have been reported, it has been observed twice in the Vermilion Pass burn during the nesting season. Other reports are at Saskatchewan Crossing and Vermilion Lakes. It prefers open forests and burns with dead trees, mainly in the Montane Ecoregion, although it has been seen in the Subalpine.

Western Flycatcher (*Empidonax difficilis*)

The Western Flycatcher is a rare summer resident of BNP and occurs in Alberta in the mountains and foothills from about JNP south. In BNP, there is one nesting record at Johnston Creek in 1978 and sightings from along the Bow River, lower Spray River, Mistaya River and Alexandra River. It is a definitive species in Bird Community 4 and Bird Community 5 which are associated primarily with open coniferous forests near streams and seepages in the Montane and Lower Subalpine.

Steller's Jay (*Cyanocitta stelleri*)

The Steller's Jay is a rare, year-round resident, although there are no nesting records. In Alberta, it occurs in the Rocky Mountains and in BNP there are 30 to 40 records, mostly from the western portion of the park, particularly Bryant Creek, Healy Creek and the middle Bow River. It usually occurs in mixed or coniferous forests and avalanche slopes of the Montane and Lower Subalpine and, in winter, is seen around the townsite and garbage dumps.

House Wren (*Troglodytes aedon*)

The House Wren is a rare summer resident of BNP which breeds throughout Alberta (Salt and Salt 1976). It occurs in good numbers over much of North America but occupies a very restricted habitat in BNP. Only two records exist for BNP: a single bird at Banff townsite in May 1965 (Gordon 1975) and a single bird on the lower Howse River in July 1979.

Rock Wren (*Salpinctes obsoletus*)

The Rock Wren is a rare summer resident of BNP which breeds in Alberta south of the Red Deer River and, in the mountains, north to Jasper (Salt and Salt 1967). It is also a rare summer resident in Kootenay National Park (Poll *et al.* 1984). There are only two records for BNP, one from near Saskatchewan Crossing in 1978 and one near Healy Creek in 1978; neither were nesting records. Rock Wrens occur on south-facing rock slides and bluffs in the Montane and Lower Subalpine Ecoregions.

Red-eyed Vireo (*Vireo olivaceus*)

The Red-eyed Vireo is a rare summer resident of BNP which occurs more commonly throughout Alberta and North America (Salt and Salt 1976). It is also a rare summer resident in Kootenay National Park and a very rare migrant in Yoho National Park (Poll *et al.* 1984). From 1975 to 1979 there are 17 records in BNP of only single birds, although at least nine were singing males (Holroyd and Van Tighem 1983). The records are from the middle and lower Bow Valley, lower Cascade River and a 1943 record from Windy Cabin. The Red-Eyed Vireo is a definitive species of Bird Community 3 and is also a member of Bird Community 1 and Bird Community 9. It typically occurs in poplar forest and shrub communities of the Montane Ecoregion which are restricted habitats in BNP and account for its low numbers in the park.

Rusty Blackbird (*Euphagus carolinus*)

The Rusty Blackbird is a rare resident which occurs throughout Canada and breeds commonly in northern Alberta and less commonly in central and southwestern parts (Salt and Salt 1976). There are no recent summer records but it has been recorded several times recently in the fall and winter at Banff townsite and Vermilion Lakes. Its rarity in the park is likely due to its preference for wetlands and pond margins which are restricted habitats in BNP.

Magnolia Warbler (*Dendroica magnolia*)

The Magnolia Warbler is a rare summer resident of BNP which breeds in the northern half of Alberta and in the mountains south to Banff (Salt and Salt 1967). There are no nest records from BNP, however there are twelve sightings, including singing males, mostly from Banff townsite and Vermilion Lakes but also from the lower Cascade River, middle Bow River and upper North Saskatchewan River valleys. The Magnolia Warbler is a definitive species of Bird Community 4 and occurs in open coniferous and mixed forests in the Montane and Lower Subalpine Ecoregions.

Rare Migrant Species

This section includes 28 species which at maximum abundance in BNP are rare spring or fall migrants (Holroyd and Van Tighem 1983). Thirteen species are reported from Vermilion Lakes, 22 from the lower Bow River (east gate to Vermilion Lakes), six from the middle Bow River (Vermilion Lakes to Lake Louise) and four from the Saskatchewan Crossing area. This indicates the great importance of the Montane Ecoregion, particularly the waterbodies, to migrating birds in BNP and emphasizes the need to minimize further disruptions of the Montane Ecoregion.

Whistling Swan (*Olor columbianus*)

The Whistling Swan is a rare spring and fall migrant in BNP, although it is a more common migrant in central and eastern Alberta (Salt and Salt 1976). It occurs mostly on ponds and lakes of the Montane and Lower Subalpine Ecoregions, most frequently at Vermilion Lakes.

Trumpeter Swan (*Olor buccinator*)

The Trumpeter Swan is a rare spring migrant in BNP which breeds in the Peace River and Cypress Hills areas of Alberta (Salt and Salt 1976). The species was nearly extinct at the beginning of this century but is now slowly increasing in numbers. Only one record, June 1943 at Vermilion Lakes, exists for BNP in the last 40 years.

Red-breasted Merganser (*Mergus serrator*)

The Red-breasted Merganser is a rare spring and fall migrant in BNP which breeds in northeastern and perhaps northcentral Alberta and is a common migrant in the rest of the province (Salt and Salt 1976). Recent records in BNP are from the Vermilion Lakes, lower Bow River and lower North Saskatchewan River.

Rough-legged Hawk (*Buteo lagopus*)

The Rough-legged Hawk is a rare spring and fall migrant in BNP which commonly migrates through central and eastern Alberta (Salt and Salt 1976). From 1978 to 1983, it was seen nine times in BNP in the Bow Valley and along the Clearwater River. With increased monitoring emphasis in 1984, it was recorded 27 times (Davidson 1985b). It is seen most commonly in the Montane and Subalpine Ecoregions near river floodplains.

Prairie Falcon (*Falco mexicanus*)

The Prairie Falcon is a rare fall migrant in BNP which breeds throughout the prairies and foothills in Alberta (Salt and Salt 1976). Twelve were observed in BNP between 1976 and 1984 with most sightings in the Front Ranges (Fig. 4).

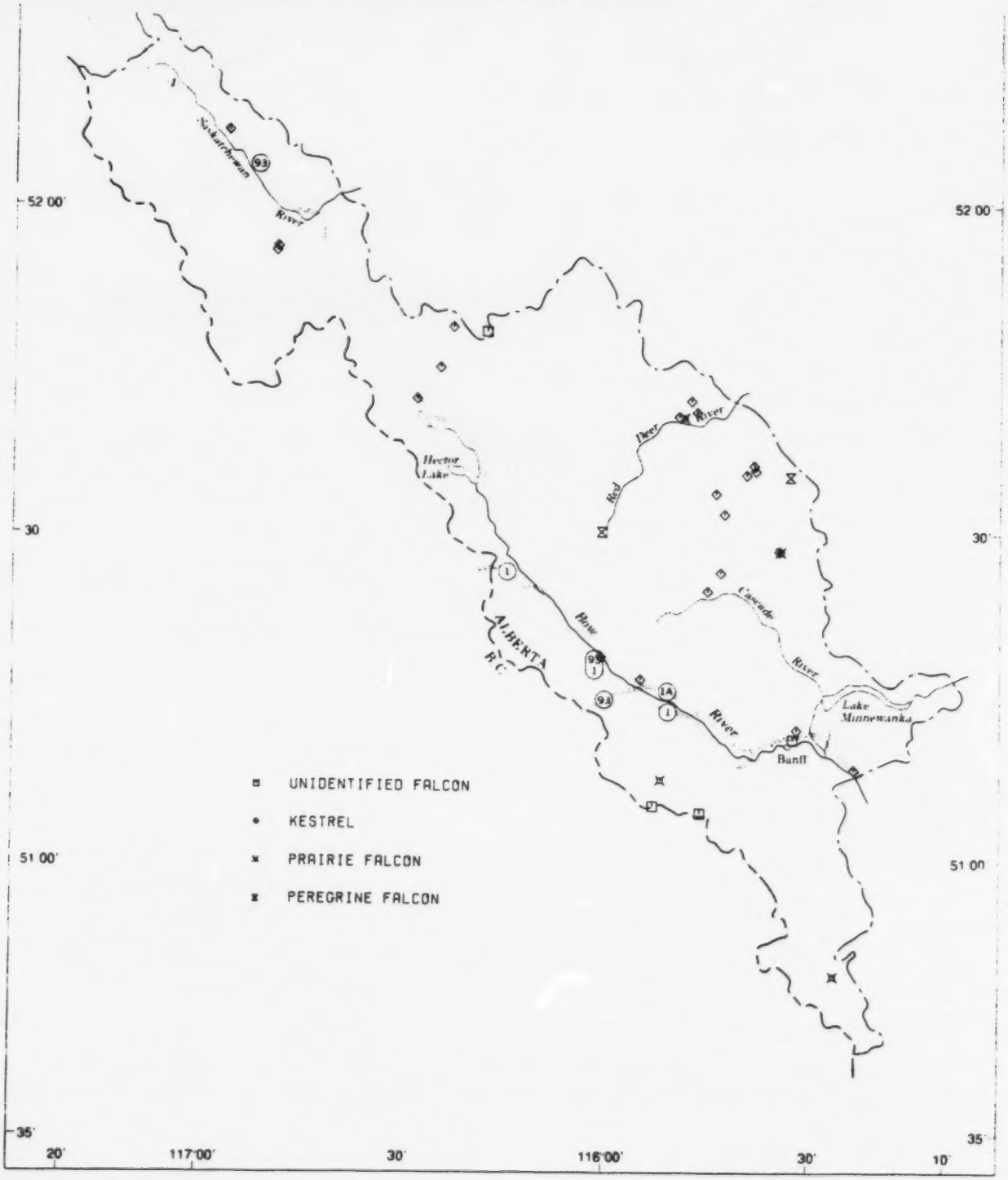
Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is a rare spring and fall migrant, and a rare summer visitor in BNP. It formerly was a fairly common breeder in Alberta until the 1950's when its numbers declined greatly (Salt and Salt 1976). Alberta birds are of the subspecies *Falco peregrinus anatum* which is endangered (COSEWIC 1985). A captive breeding and release program by 1980 had re-established nine nesting pairs in Alberta (Alberta Fish and Wildlife 1984), although none are in national parks. Sightings since 1976 have been of single birds from the upper Spray River, Dormer River, lower Panther River and Parker Ridge (Fig. 4). Pairs have been seen at Baker Lake in 1984 and upper Lost Horse Creek in 1985 (Warden Wildlife Files 1977 - 1985).

Golden Plover (*Pluvialis dominica*)

The Golden Plover is a rare spring migrant in BNP which is a regular spring and fall migrant in Alberta east of the mountains. Only two sightings are reported for BNP, both from Vermilion Lakes. Four sightings are known from JNP, all in the fall in the lower Athabasca Valley.

Fig. 4. Falcon observations in Banff National Park, 1975-1984.



Upland Sandpiper (*Bartramia longicauda*)

The Upland Sandpiper is a rare fall migrant in BNP which breeds east of the foothills in Alberta (Salt and Salt 1976). Only two records are known for BNP, upper Siffleur River in 1943 and the Indian Grounds at Banff in 1970. It occurs primarily in grasslands.

Sanderling (*Calidris alba*)

The Sanderling is a rare fall migrant in BNP, although it is a common spring and fall migrant east of the mountains in Alberta (Salt and Salt 1976). The only BNP record is from Lake Helen in September 1975.

Short-billed Dowitcher (*Limnodromus griseus*)

The Short-billed Dowitcher is a rare fall migrant in BNP which breeds in Alberta north of Edmonton (Salt and Salt 1976). BNP sightings are from Waterfowl Lakes and Wigmore Lake both in the Lower Subalpine Ecoregion.

Wilson's Phalarope (*Steganopus tricolor*)

The Wilson's Phalarope is a rare spring and fall migrant in BNP which breeds east of the mountains in Alberta (Salt and Salt 1976). It is seen regularly in the lower Bow Valley, especially Vermilion Lakes. All records are from ponds and lakes in the Montane Ecoregion.

Northern Phalarope (*Lobipes lobatus*)

The Northern Phalarope is a rare spring and fall migrant in BNP although it is a common migrant east of the mountains in Alberta (Salt and Salt 1976). BNP records are from Vermilion Lakes, Johnson Lake, the lower Bow River and Redoubt Lake. It occurs primarily along the edge of ponds, lakes and rivers.

Mew Gull (*Larus canus*)

The Mew Gull is a rare fall migrant in BNP with only one record known (September 1979). It is a casual migrant in most of Alberta but is a common summer visitor in northernmost Alberta (Salt and Salt 1976).

Franklin's Gull (*Larus pipixcan*)

The Franklin's Gull is a rare spring and fall migrant in BNP which breeds in most of Alberta east of the mountains (Salt and Salt 1976). BNP records are from the lower Bow Valley, including Vermilion Lakes, the Indian Grounds and Lake Minnewanka.

Bonaparte's Gull (*Larus philadelphia*)

The Bonaparte's Gull is a rare spring and fall migrant in BNP which breeds in central and northern Alberta (Salt and Salt 1976). It occurs irregularly in Front Range valleys, most often at Vermilion Lakes.

Sabine's Gull (*Xema sabini*)

The Sabine's Gull is a rare fall migrant in BNP and is a rare, but regular, spring and fall migrant in most of Alberta (Salt and Salt 1976). It is also a rare migrant in JNP. The only BNP record is from Vermilion Lakes.

Forster's Tern (*Sterna forsteri*)

The Forster's Tern is a rare spring and fall migrant in BNP which breeds locally in central and southern Alberta (Salt and Salt 1976). Only three BNP records are known, all from Vermilion Lakes.

Black Tern (*Chlidonias niger*)

The Black Tern is a rare spring migrant in BNP which breeds throughout Alberta east of the mountains (Salt and Salt 1976). It has been observed in BNP only three times, twice at Vermilion Lakes and once

at Banff townsite.

Snowy Owl (*Nyctea scandiaca*)

The Snowy Owl is a rare fall migrant in BNP which is a regular winter visitor to much of Alberta east of the mountains (Salt and Salt 1976). Only three observations are recorded, one from Waterfowl Lakes and two from Lake Louise.

Say's Phoebe (*Sayornis saya*)

The Say's Phoebe is a rare spring and fall migrant in BNP which breeds in southern and central Alberta east of the mountains (Salt and Salt 1976). BNP records of this species are from the Banff townsite vicinity and lower Cascade River.

Nashville Warbler (*Vermivora ruficapella*)

The Nashville Warbler is a rare spring and fall migrant in BNP which breeds from southern Canada south into the United States (Salt and Salt 1976). It is not known to breed in Alberta and the most frequent sightings in the province are from Vermilion Lakes.

Palm Warbler (*Dendroica palmarum*)

The Palm Warbler is a rare spring and fall migrant in BNP which breeds in northern and central Alberta east of the mountains (Salt and Salt 1976). Only two records are known for BNP, one at Vermilion Lakes and the other at Healy Creek, both in forested Montane wetlands.

Western Meadowlark (*Sturnella neglecta*)

The Western Meadowlark is a rare spring and fall migrant in BNP which breeds in central and southern Alberta east of the mountains (Salt and Salt 1976). BNP observations are from the Bow Valley, lower Cascade River and Saskatchewan Crossing. It is also a rare summer visitor which has been seen at Banff townsite and Indianhead cabin. It occurs mostly in dry grasslands.

Common Grackle (*Quiscalus quiscula*)

The Common Grackle is a rare fall migrant in BNP which breeds throughout Alberta east of the mountains, although it is local and scarce in the prairies (Salt and Salt 1976). The only BNP record is from Banff townsite in the fall of 1974.

Sharp-tailed Sparrow (*Ammospiza caudacuta*)

The Sharp-tailed Sparrow is a rare fall migrant in BNP which breeds locally across northern Alberta (Salt and Salt 1976). The only BNP record is from Graveyard Flats on the North Saskatchewan River in 1945.

Tree Sparrow (*Spizella arborea*)

The Tree Sparrow is a rare spring and fall migrant in BNP although it is a common migrant east of the mountains in Alberta (Salt and Salt 1976). Sightings in BNP are from Banff townsite, the Mistaya River and the Alexandra River.

Swamp Sparrow (*Melospiza georgiana*)

The Swamp Sparrow is a rare spring and fall migrant in BNP which breeds locally in central and northern Alberta (Salt and Salt 1976). Only four sightings of this species are reported in BNP, three at Banff townsite and one at Lake Louise.

Chestnut-collared Longspur (*Calcarius ornatus*)

The Chestnut-collared Longspur is a rare spring migrant in BNP which breeds in the prairies of southern and central Alberta (Salt and Salt 1976). The only BNP record is from the middle Bow Valley in 1943.

Other Significant Birds

This section includes four uncommon species with restricted distributions in the park and a species of scientific interest.

Red-necked Grebe (*Podiceps grisegana*)

The Red-necked Grebe breeds throughout Alberta except for the prairies south of about Calgary and is uncommon in the mountains. It has recently declined in numbers across North America, *i.e.* is a Blue List species, and is under consideration as a threatened species in Canada. In BNP, nesting occurs only at Vermilion Lakes where usually no more than two pairs are present. The species is more common during migration. Increased survey effort in 1984 yielded seven sightings at Vermilion Lakes, three at Lake Minnewanka, three at Two Jack Lake and two at Johnson Lake (Davidson 1985a).

Red-necked Grebes prefer shallow water with extensive beds of emergent vegetation in the Montane and Lower Subalpine Ecoregions. Emergent vegetation should be protected from disturbance by boaters and fishermen, and disturbance of nests should be prevented.

Pied-billed Grebe (*Podilymbus podiceps*)

The Pied-billed Grebe breeds throughout Alberta but is uncommon in the mountains (Salt and Salt 1967). There are only two breeding records from BNP; both are from Vermilion Lakes, one in 1968 and the other in 1979. It has also been seen in the Cave and Basin Swamp (Holroyd and Van Tighem 1983) and at Rainy Bay (Davidson 1985a). It occurs in the Montane Ecoregion on ponds, backwaters and lakes which have beds of sedge, rushes, norsetail or flooded willow thickets along the margins.

Golden Eagle (*Aquila chrysaetos*)

The Golden Eagle is an uncommon summer resident and a rare winter resident of BNP (Fig. 5) which is less abundant now than formerly. There was an estimated minimum of five to seven breeding territories in the valleys of the Bow River and Spray River in 1977 (Holroyd and Gartshore 1978). Recent nesting is known from the Panther River in 1980 and 1982, and Bryant Creek in 1983 and 1984, and is suspected in the Bourgeau Lake and Flints Park areas. Most nests occur on ledges of steep cliffs with a southerly aspect in the Subalpine Ecoregion. Nests are not used consistently year after year and may be abandoned after one or two seasons. Causes of abandonment are not always clear but human disturbance can cause failure and abandonment especially if disturbance occurs early in the nesting period (Fyfe and Olendorff 1976). Young are much sought by falconers (Beebe 1974) and nest locations should be kept confidential.

Osprey (*Pandion haliaetus*)

The Osprey breeds throughout the forested part of Alberta, although it is increasingly rare and local in central Alberta (Salt and Salt 1978) and is a Blue List species. In BNP, it is restricted to the Montane Ecoregion of the Bow Valley where five nesting territories are known to have been used since 1970 (Fig. 3). Ospreys feed on fish and thus nest along lakes and rivers where they use tall coniferous trees or, sometimes, power poles. They are vulnerable to disturbance while nesting.

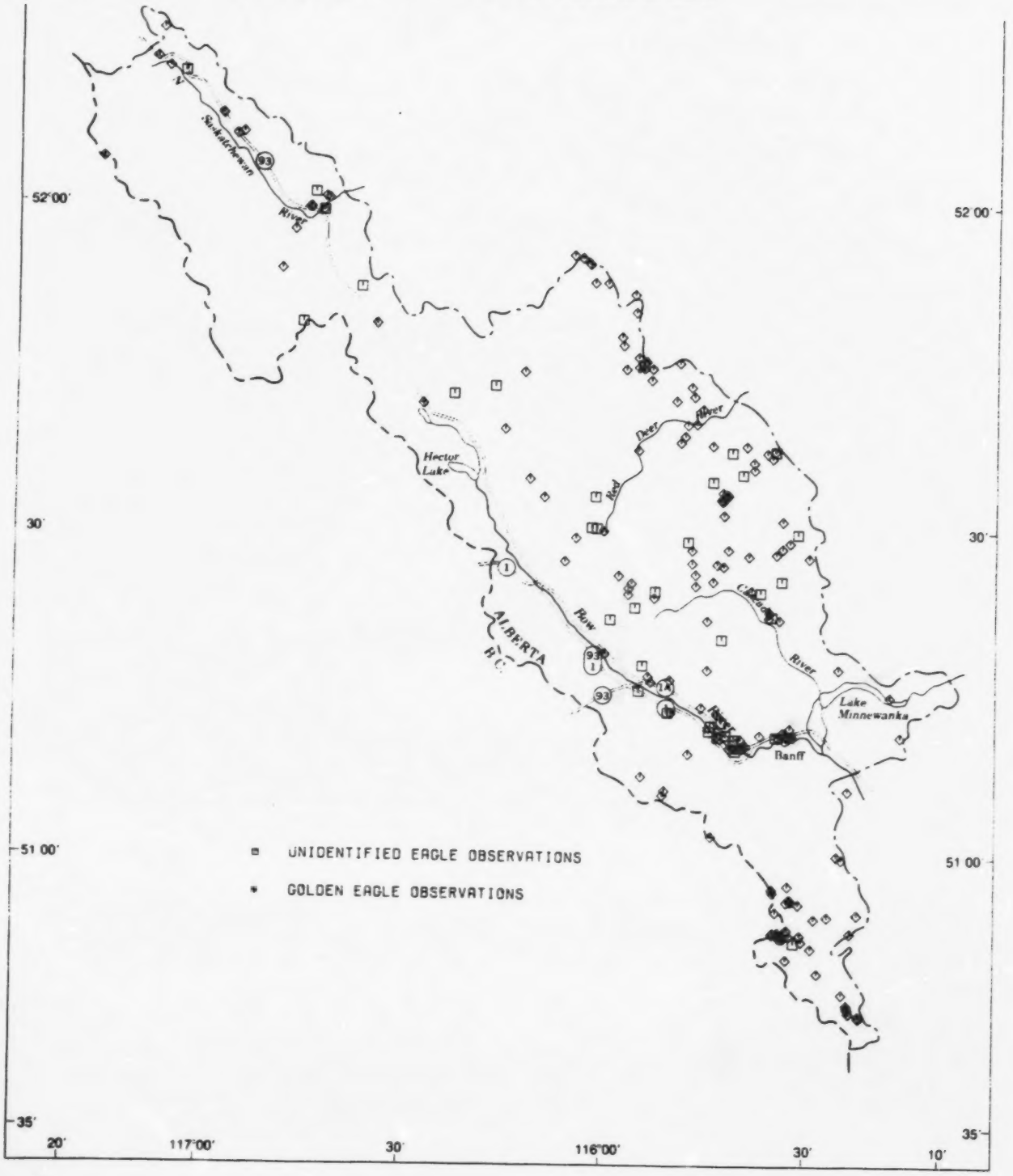
Cliff Swallow (*Petrochelidon pyrrhonota*)

The Cliff Swallow is a common summer resident in BNP which breeds throughout Alberta (Salt and Salt 1976). It nests in colonies of 50 to 100 birds and is one of the most common swallows in BNP. Two colonies are of scientific interest because they are in the Alpine Ecoregion, one at Redoubt Lake and the other at Devon Lakes. No other swallows are known to nest in the Alpine and these colonies should be protected from any disturbance.

Significant Bird Communities

During the ecological land classification of BNP, 18 Breeding Bird Communities were recognized on the basis of the occurrence of characteristic combinations of bird species in vegetation types (Holroyd and Van Tighem 1983). These communities thus provide an indication of bird habitat units in the park. Four of these communities have a very restricted areal extent in BNP and should receive special

Fig. 5. Golden Eagle sightings in Banff National Park, 1975-1984.



management attention to ensure that they are not further reduced in size. All four are associated mostly or entirely with the Montane Ecoregion, particularly in the lower Bow Valley. This portion of BNP has already been greatly impacted by development and great care will be needed to conserve the remaining fragments.

Bird Community 1

Bird Community 1 is typified by species such as American Robin, Warbling Vireo, Tree Swallow, Swainson's Thrush and Brown-headed Cowbird. It includes many species which occur in no other bird community in BNP and the following species reach their greatest densities in this community: Cooper's Hawk, Ruffed Grouse, Long-eared Owl, Mourning Dove, Yellow-bellied Sapsucker, Western Wood Peewee, American Robin, Black-capped Chickadee and Warbling Vireo. Two Blue List species, Cooper's Hawk and Common Nighthawk, occur in this community.

Bird Community 1 is associated with aspen and balsam poplar forests, including the C16, C17 and C22 vegetation types (Achuff and Corns 1982). This habitat occurs mostly on south-facing slopes in the Montane Ecoregion of the Bow Valley and North Saskatchewan River valley, with a small amount occurring in the lower part of the Lower Subalpine.

Bird Community 3

Bird Community 3 characteristically includes Dark-eyed Junco, Pine Siskin, Yellow-rumped Warbler and Chipping Sparrow. Mountain Chickadee, American Robin, Bohemian Waxwing, Solitary Vireo, Western Tanager and Dark-eyed Junco reach their highest densities in this community. Calliope Hummingbird and Red-eyed Vireo which are rare species in BNP are also members of this community.

The community is associated with Douglas fir forests (C1 and O5) which are restricted to the Montane Ecoregion and which are also significant vegetation types (section 4.1.3).

Bird Community 9

Bird Community 9 is characterized by species such as Northern Yellowthroat, Red-winged Blackbird, Lincoln's Sparrow, Common Crow, Mallard Duck and Ring-necked Duck. It has the highest density of birds of any community in the park and is thus one of the most important. It is particularly notable for waterfowl and species which reach their highest densities here include Canada Goose, Mallard Duck, Blue-winged Teal, Ring-necked Duck and Common Merganser. Another 23 species also reach maximum densities in this community. Six are Blue List species: Red-necked Grebe, American Bittern, American Kestrel, Willow Flycatcher, Yellow Warbler and Common Yellowthroat, and two are rare in BNP: American Bittern and Red-eyed Vireo.

Bird Community 9 occurs in shrubby wetlands in the Montane Ecoregion often in association with lakes and ponds. It is very restricted areally and is almost wholly confined to tracts of the VL Ecosection (Holland and Coen 1982) in the Bow Valley.

Bird Community 13

Bird Community 13 is typified by species such as Calliope Hummingbird, Warbling Vireo, Swainson's Thrush, Vesper Sparrow and Orange-crowned Warbler. Four species attain highest densities in this community: Calliope Hummingbird, Common Flicker, Vesper Sparrow and Dark-eyed Junco. The Calliope Hummingbird is also a rare species in BNP.

Bird Community 13 is very restricted in areal extent and is associated with dry grasslands of the Montane Ecoregion. This habitat typically includes the H6 and H7 vegetation types which are themselves significant features in BNP (section 4.1.3). It occurs most commonly in the lower Bow Valley.

4.2.5 Mammals

Two categories of mammals are identified as special features in this section. ***Rare mammals*** have a small population and restricted distribution in BNP, or occur infrequently throughout their range, or are ***rare***, ***threatened*** or ***endangered*** in Canada (COSEWIC 1985). ***Other significant mammals*** have either a restricted distribution in BNP or a restricted distribution nationally or internationally, often due to loss of habitat.

In the species accounts below, information is from Holroyd and Van Tighem (1983) unless otherwise cited. The maps show the number of observations reported by Warden Wildlife cards from 1976 to 1984 rather than the number of animals observed. There is some bias in the observations due to travel patterns and different staffing levels throughout the park.

Management recommendations are not intended to increase population sizes of rare or significant mammals, rather they will minimize negative, man-caused impacts and restore ecosystems as natural processes prevail. Several aspects, which apply to all the species accounts below, include the recognition that:

1. unnatural mortality from transportation corridors needs to be reduced

2. fire is an important natural process in Rocky Mountain ecosystems and prescribed fire is necessary to duplicate natural processes which maintain high quality wildlife habitat

3. the status, distribution and habitat requirements of most of the small mammals are so poorly known that very few, if any, management recommendations can be made at this time.

Rare Mammals

Water Shrew (*Sorex palustris*)

Water shrews are very rare but widespread in BNP with collections from the middle Bow Valley, Johnston Creek, Spray River (Eightmile cabin), Redearth Creek, Healy Creek and Moraine Lake. They occur from the Montane to the Upper Subalpine in habitats that include mossy spruce-fir forests, shrubby open forests and shrub communities near fast cold streams. This species is also rare in Kootenay National Park (Poll *et al.* 1984).

Pygmy Shrew (*Microsorex hoyi*)

Pygmy shrews are rare or very rare in BNP. Information on this species in BNP is based on only two specimens that were collected during the ecological land classification (Holroyd and Van Tighem 1983), one from the Healy Creek backswamp and one from the lower end of the Bourgeau Lake trail. These sites should be considered critical for the species in BNP. With so few records, an accurate description of their habitat is not possible. Pygmy shrews are also rare in Kootenay National Park (Poll *et al.* 1984).

Silver-haired Bat (*Lasionycteris noctivagans*)

Silver-haired bats occur in Canada from the Atlantic coast to the Queen Charlotte Islands in the summer. It is a rare species in BNP and known from only two specimens. One, from Banff townsite in 1973, was rabid (Schowalter 1976) and the other was from the Spray River (Holroyd and Van Tighem 1983). None were trapped or detected ultrasonically during the ecological land classification (Holroyd and Van Tighem 1983), although one was found in Kootenay National Park (Poll *et al.* 1984) and one was captured in Glacier National Park (Van Tighem and Gyug [1984]). This species migrates south in late August to early September. Its mountain habitats are unknown, but it may be more common in the northern Rockies (Poll *et al.* 1984).

Hoary Bat (*Lasiurus cinereus*)

Hoary bats occur in southern Canada from June to August. It is an uncommon species in Alberta with most reports from south of Edmonton. In BNP, it is rare with records from the Banff townsite area and Stoney Creek (Holroyd and Van Tighem 1983). Hoary bats are a solitary, tree-dwelling species which forage over open forests and lakes.

Richardson's Water Vole (*Arvicola richardsoni*)

Richardson's water vole occurs in the southern Rockies and southcentral British Columbia in Canada. In BNP, it is rare to uncommon (Holroyd and Van Tighem 1983) and occurs in the southern and central parts of the park in the upper Spray River, Johnston Creek, Panther River, Pipestone River, Healy Creek and the middle and upper Bow River watersheds. Typical habitat for this species includes Upper Subalpine herb and shrub meadows close to water and late snow patches. It is rare or absent in Kootenay National Park (Poll *et al.* 1984).

Timber (Grey) Wolf (*Canis lupus*)

Before 1700, wolves were the most widely distributed mammal in North America, inhabiting every biome (Young 1944). However, they have been eliminated from about half of their former range. In Canada, wolves occurred in every region except the Queen Charlotte Islands. They are now extirpated from the southern part of their range from British Columbia to Quebec, the Maritimes and Newfoundland (Banfield 1974).

Wolf numbers in Alberta are presently estimated at 5000 (Alberta Fish and Wildlife 1984). Wolves are presently very rare in the southern Canadian Rockies, but are increasingly common further north, especially in the Front Ranges of BNP and throughout JNP (Holroyd and Van Tighem 1983).

In the Canadian Rockies, wolf control began by 1859 and numbers were greatly reduced by the 1930's. The species showed an increase in the northern portion of its range between 1930 and 1950. In BNP, numbers rose rapidly in the late 1940's coincident with a rise in the elk population. Numbers peaked in 1947 at 48 (Green 1951) and in 1948 wolf control was renewed in BNP. Control efforts were intensified in 1952 following a rabies outbreak in Alberta (Kaye and Roulet 1982). By 1953 the population in BNP was at most 15 animals (Green 1951). Wolf control was discontinued in 1953 (Green 1955a).

Wolves were slow to repopulate their former ranges in the park; the BNP population was fewer than 10 animals from 1954 to 1970 (Karasiuk n.d.). In 1971, a pack began using the lower Clearwater River and between 1976 and 1980, there were 18 observations of 26 animals (Fig. 6). The number of lone sightings and locations suggest that many of these were stragglers from outside BNP. The first recent evidence of denning in the park was in 1980 (Holroyd and Van Tighem 1983). Since then, observations have increased with denning confirmed in 1981 to 1984 in the Front Ranges. There were 170 observations of 270 wolves during this four year period, primarily in the Front Ranges (Fig. 6). No dens were observed in the park in 1985, although wolves may have denned on the Ya Ha Tinda ranch (Mickle 1985). Although resident packs have not re-established in the Bow Valley, there have been consistent observations during the winters of 1982 to 1986. An estimated 25 to 35 wolves were in or adjacent to BNP during winter of 1984-1985 (Mickle 1985).

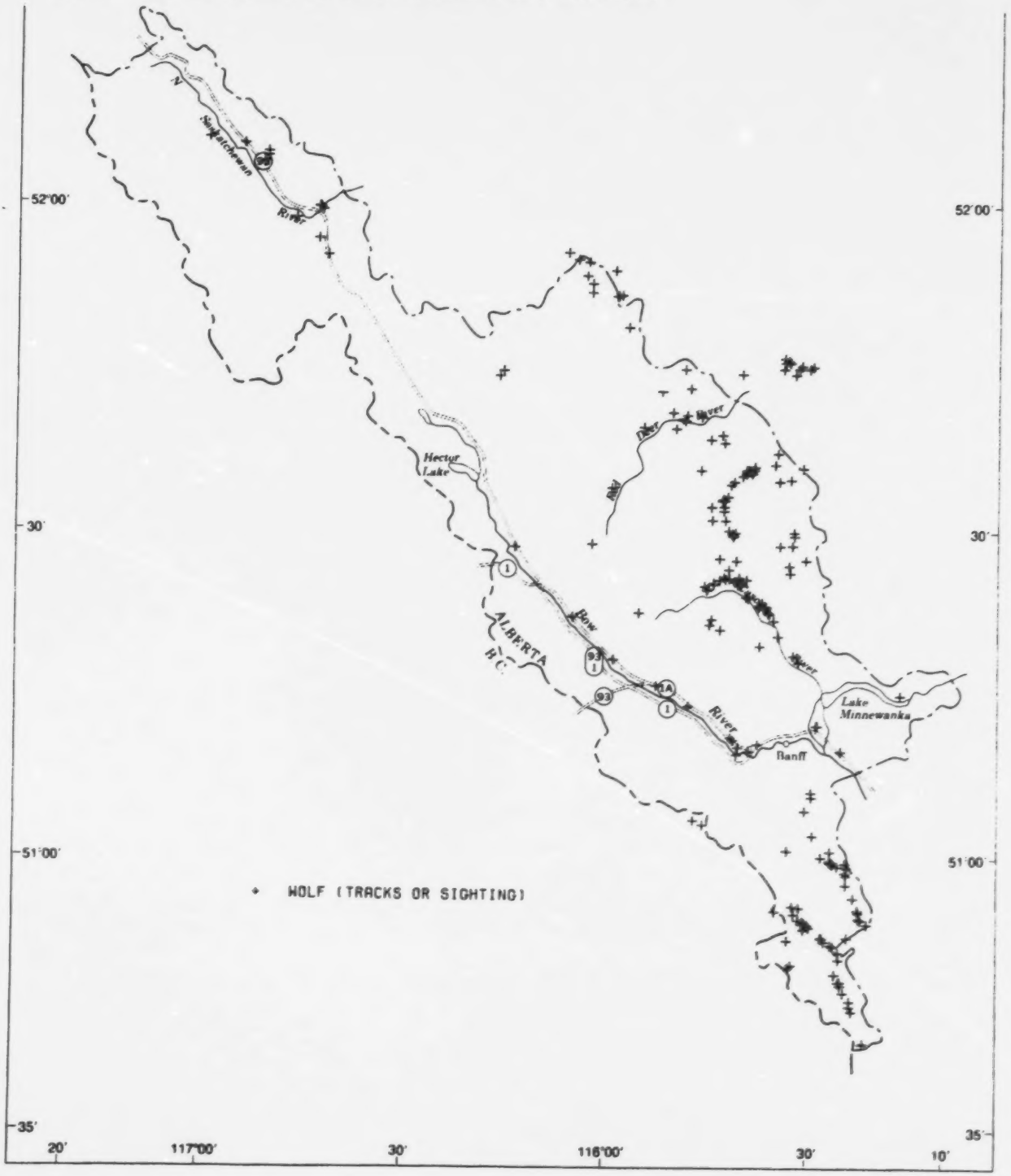
Protection of denning areas is critical to the re-establishment and maintenance of wolves in the park. As wolf numbers in BNP increased in the late 1940's, dens were reported from the Bow Valley (1945, 1947), Panther River (1946), Ya Ha Tinda (1948) and Cascade River (1949-1950). Wolf control from 1948 to 1953 again reduced the population and no active dens were known in the park until the 1970's. Recently, denning is known or suspected to have occurred on the lower Red Deer River (1974), Panther River (1982-1984), lower Spray River (1983), and Ya Ha Tinda (1985).

Dens are most commonly a burrow excavated on a promontory near water. Less frequently, an overhanging rock shelf or cave is used (Banfield 1974). Wolf behavior in relation to human disturbance appears to vary greatly. Sometimes they den near areas of human activity such as highways and, in other cases, they are very sensitive to human intrusion. Carbyn (1974) mentions four cases in which wolves left dens after being disturbed or accidently approached to within 150 to 200 m. Wolves are most vulnerable to disturbance during the denning and rendezvous periods from mid-April to late July (Holroyd and Van Tighem 1983). After the natal den is abandoned in mid-June, the adults move the pups to a series of rendezvous sites until August when the pups begin to travel with the pack. Rendezvous sites and dens may be reused year after year if undisturbed. Rendezvous areas in the park are not known.

Wolf activity should be monitored from late February to early May to identify denning areas. If human disturbance of a den appears likely, the area should be closed. The location of dens and rendezvous sites should be confidential.

Wolves which den or reside in BNP for much of the year, often range east of the park boundary in the winter where they may be legally shot, trapped or poisoned. Three wolves were killed in this way in the fall and winter of 1984-1985 (Skjonsberg 1985). Presently there is not widespread predator control on adjoining provincial lands. Wolf predation on domestic livestock is uncommon and no control measures are taken if the site is more than 20 km east of the Green Area boundary (Clarkson 1982). Wolves have never been controlled on provincial lands in Alberta for game management purposes (Clarkson 1982). However, Alberta Fish and Wildlife is presently studying wolf predation on ungulates in the Nordegg area (Schmidt and Gunson 1985). Provincial measures appear to have little influence on the status of wolves in BNP currently, but efforts should be made to establish a cooperative wolf management zone in the East Slopes to reconcile the differing management objectives of Parks Canada and Alberta Fish

Fig. 6. Wolf observations in Banff National Park, 1975-1984.



and Wildlife.

Red Fox (*Vulpes velox*)

Red foxes are generally rare and sparsely distributed in the Rocky Mountains and, in BNP, they are very rare (Holroyd and Van Tighem 1983). Observations from 1945 to 1976 (Warden Wildlife Files 1945 - 1976) total 12 animals, include two highway mortalities and were primarily from the Bow Valley. Reports since then (Warden Wildlife Files 1977 - 1985) include the Spray River, Mistaya River and Clearwater River valleys as well (Fig. 7). Of nine reports since 1979, four have been highway fatalities (Warden Wildlife Files 1977 - 1985). For a species this rare, this level of unnatural mortality is very significant.

Red foxes occur primarily in the Montane and Lower Subalpine of large valleys, although they occur occasionally into the Alpine Ecoregion. They appear limited to the Montane in winter due to deep snow at higher elevations. Little is known of their ecology in the mountains and no dens are known from BNP, although they probably do breed in the park. Their low numbers may be due to competition for food by wolves and coyotes (Holroyd and Van Tighem 1983) and it is likely that red foxes will remain rare in BNP.

Highway mortality may decrease as fencing of the Trans-Canada Highway in the lower Bow Valley reduces the availability of road-killed ungulates. Continued removal of such carcasses will likely further reduce highway mortality.

Fisher (*Martes pennanti*)

Fishers occur in low numbers in the forested areas of Alberta. They are rare in the Rocky Mountains generally and very rare in BNP. They are also very rare in JNP and Yoho National Park and may be extirpated in Kootenay National Park and Waterton Lakes National Park (Holroyd and Van Tighem 1983). Fishers have probably always been rare in BNP. Early reports (Anderson 1938, Clarke 1940) do not mention fishers and between 1944 and 1976, only five observations were recorded. Between 1976 and 1984, only single sightings from the lower Clearwater River, Mistaya River, and middle Bow River are known (Warden Wildlife Files 1977 - 1985). In addition, tracks were noted at Bryant Creek, the upper North Saskatchewan River, Siffleur River, middle Bow River and upper Spray River during this latter period.

Fishers occur mainly in mature, closed coniferous forests of the Lower Subalpine Ecoregion (Holroyd and Van Tighem 1983). Extensive forest fires about 75 to 100 years ago depleted mature forest habitat when the species was also under severe trapping pressure, thus further reducing a naturally small population (Holroyd and Van Tighem 1983). Currently, succession has restored much mature forest, particularly near the Continental Divide. Since fishers are currently not trapped or only lightly trapped along the boundaries of BNP (Clarkson 1982), the small population size is likely the result of natural environmental conditions (Holroyd and Van Tighem 1983). Attempts to reintroduce or increase numbers of fishers would probably not be successful.

Least Weasel (*Mustela nivalis*)

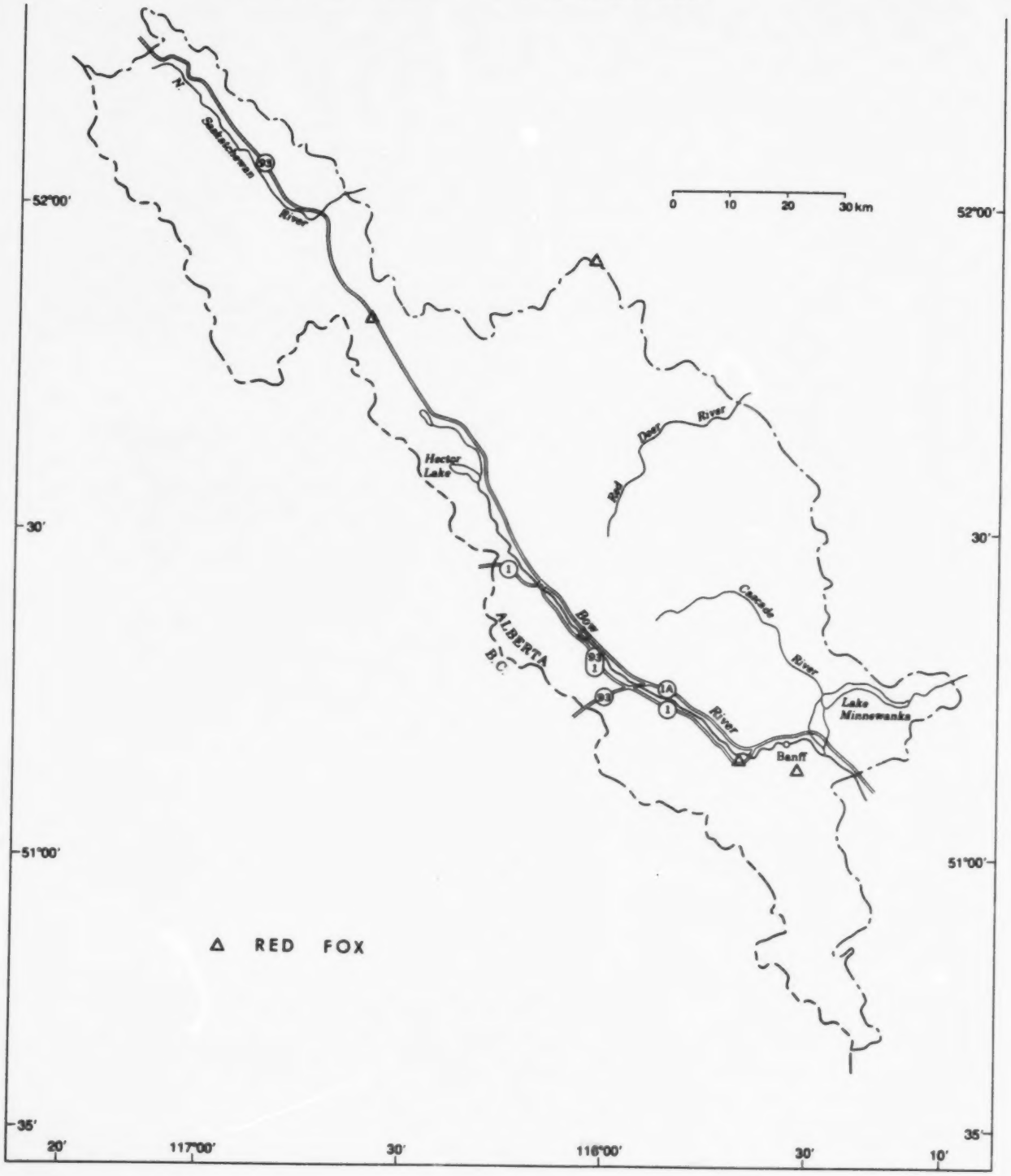
Least weasels occur over most of Alberta and are rare in the Rocky Mountains including BNP. There are only 17 records of this species in BNP, three before 1977 (Warden Wildlife Files 1945 - 1976), 11 between 1977 and 1981 (Holroyd and Van Tighem 1983) and three since 1981 (Warden Wildlife Files 1977 - 1985). Most records are from the Lower Subalpine in pine-spruce and spruce-fir forests (Holroyd and Van Tighem 1983).

Long-tailed Weasel (*Mustela frenata*)

Long-tailed weasels occur widely in North America but are uncommon in the Rocky Mountains. They are a threatened species in Alberta (COSEWIC 1985) and are uncommon in BNP (Holroyd and Van Tighem 1983). Between 1968 and 1976, six records were reported from BNP, from 1976 to 1981 there were 17 records, and from 1982 to 1984 there were four observations (Warden Wildlife Files 1977 - 1985). They occur most commonly in Subalpine pine and spruce-fir forests, although they also occur in the Montane and Alpine Ecoregions in a wide variety of habitats.

Wolverine (*Gulo gulo*)

Fig. 7. Red fox observations in Banff National Park, 1975-1984.



In Canada, wolverines are rare (COSEWIC 1985) and they are the rarest carnivore in Alberta (Alberta Fish and Wildlife 1984). Historically, they ranged through the boreal forest from Labrador to Alaska, through the Arctic and in the western mountains into the United States. They continue to exist in low densities over much of this range but are extirpated from most of the aspen parkland as well as in southern Ontario and Quebec, and the Maritimes (Banfield 1974). Only in Manitoba are they fully protected. In other provinces, they are trapped as a furbearer and shot as a nuisance animal. The most stable populations in Canada occur in the mountains of Alberta, British Columbia and the Yukon. In Alberta, wolverines occur now in significant numbers only in the Rocky Mountains, Clear Hills and portions of the Peace River District (Holbrow 1976). They are common locally in BNP, but less common further south to Waterton Lakes National Park. In light of range reductions and population declines of the last century, areas in the Rocky Mountains are among the best remaining south of 60°N. BNP is therefore an important area for their continued survival.

Of the 249 records in BNP between 1948 and 1976, approximately one-third were from the Front Ranges and two-thirds from the Main Ranges (Karasiuk n.d.). More recently, 52 were reported between 1976 and 1980 and between 1981 and 1984, 56 were reported (Fig. 8). Important watersheds, based on winter tracking data, are Johnston Creek, Baker Creek, Healy Creek, Bryant Creek, Clearwater River and the middle Bow River.

Wolverines are territorial and require large ranges, the size of which is linked to food availability (Holbrow 1976). No data are available on home range size in BNP, but wolverines in Montana require up to 963 square kilometers (Holroyd and Van Tighem 1983) and males may have a home range of 2000 sq km (Wilson 1982). Wolverines and porcupines have parallel distributions in BNP, partly because porcupines are a major prey species, being one of the few animals in winter in the the deep snow of the Upper Subalpine. Porcupines should not be unnecessarily destroyed since they are a significant food resource for wolverines (Holroyd and Van Tighem 1983).

River Otter (*Lontra canadensis*)

Otters are very rare and possibly extirpated in BNP (Holroyd and Van Tighem 1983). Soper (1970) considered otters to be historically very scarce in the Alberta Rockies. Early faunal investigations in BNP by Anderson(1938) and Clarke (1940, 1942) did not find otters. Otters were reported on the third Vermilion Lake in 1944 (Holroyd and Van Tighem 1983) and another was reported in upper Redearth Creek in 1951 (Warden Wildlife Files 1945 - 1976). Otters were last seen in 1977 at Vermilion Lakes (Holroyd and Van Tighem 1983) and on the Sunshine road in May 1983 (Warden Wildlife Files 1977 - 1985). None were seen during the ecological land classification. It is also a rare species in Kootenay National Park (Poll *et al.* 1984), JNP (Holroyd and Van Tighem 1983), Waterton Lakes National Park (Nielsen 1973) and throughout the rest of Alberta (Soper 1964).

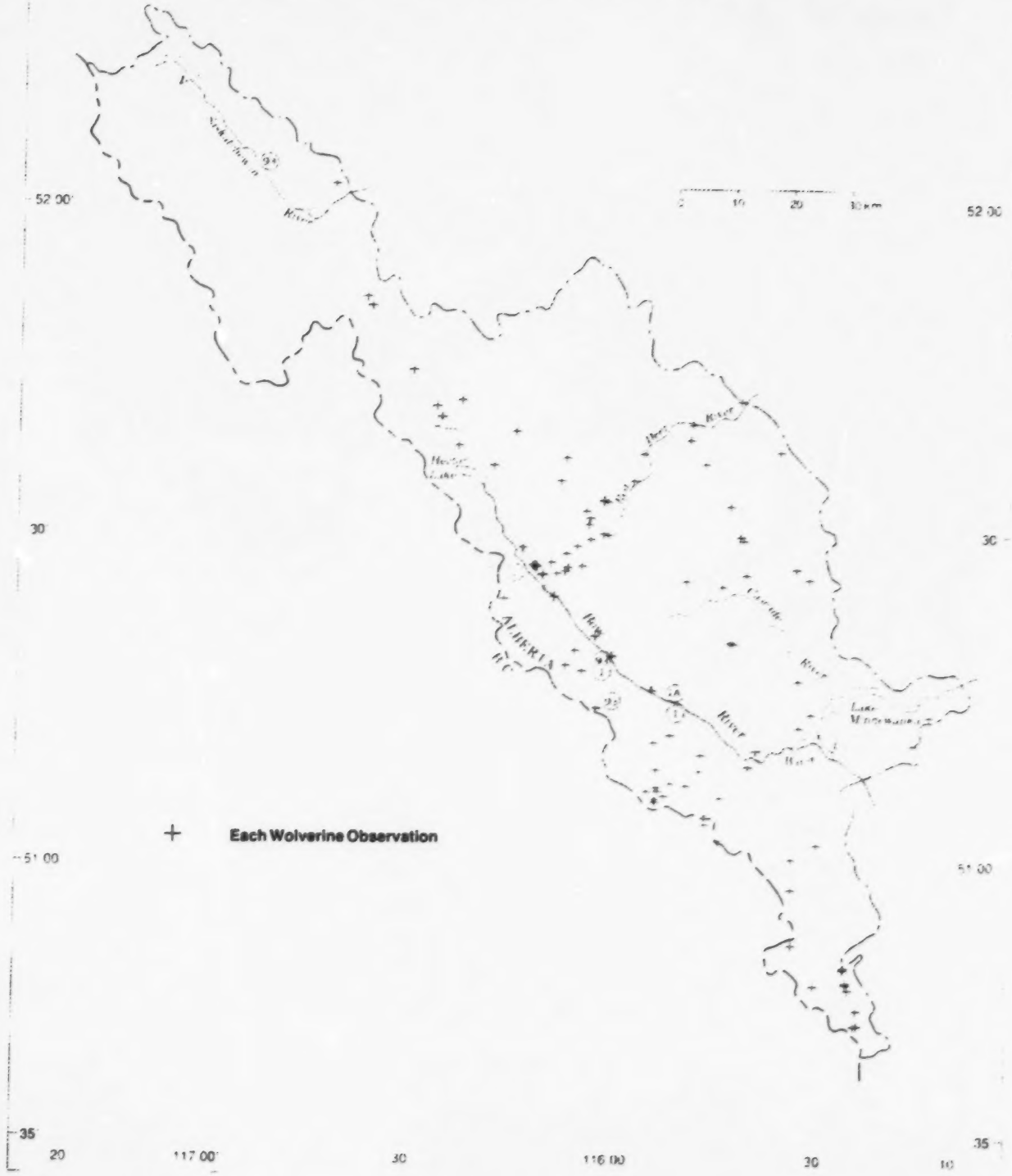
Otters inhabit marshy backwaters and floodplains in the Montane Ecoregion that are also inhabited by muskrats and beavers. In BNP, this habitat is limited to the Vermilion Lakes area. They are likely limited by the lack of open water in the winter (Jalkotzy 1980) and only occasional wanderers are likely in BNP.

Cougar (*Felis concolor*)

Cougars formerly occurred in every province except Newfoundland and Prince Edward Island (Banfield 1974). In New Brunswick, the eastern subspecies is endangered (COSEWIC 1985). The most stable populations are now in the mountains of Alberta and British Columbia (Holroyd and Van Tighem 1983). The total Alberta population, excluding those in national parks, is about 1000 animals (Alberta Fish and Wildlife 1984). In Alberta, cougars are largely confined to the Front Ranges and foothills (Holroyd and Van Tighem 1983). Historically, cougars have been more common south of the Bow River and this seems still the case. Soper (1967) estimated the number in Waterton Lakes National Park at 12. In Kananaskis Country, 28 cougars were captured in a 750 sq km area between March 1982 and April 1984 (Jalkotzy *et al.* 1984).

In BNP, tracking data suggest that cougars are very rare and it is doubtful that there is a resident population (Holroyd and Van Tighem 1983). Cougars in the park are probably immigrants from outside. For example, in May 1983 two radio collared juveniles were tracked from Kananaskis Country into BNP (Olson 1984). A small population may be resident in the Panther Corners area (McLauchlan 1985) and may account for sign and sightings in the Scotch Camp - Snow Creek Pass area. Most recent cougar observations in BNP have been in the Montane and Lower Subalpine Ecoregions, with only a few

Fig. 8. Wolverine observations in Banff National Park, 1975-1984.



in the Upper Subalpine and Alpine. Of 24 observations in BNP between 1976 and 1984, 83% were in the Front Ranges and, of these, 55% were in the Montane Ecoregion (Warden Wildlife Files 1977 - 1985) (Fig. 9). Even where cougars are relatively common, sightings are scarce because the animals are often nocturnal, solitary and wary.

There was a drastic population decline in cougar numbers in BNP in the 1930's. Between 1930 and 1937, park wardens and a professional cougar hunter killed 28 cougars in BNP, mostly in the Bow Valley. The program was discontinued in 1938 because of its success; cougars were not seen again for over a decade (Perren 1982).

In many areas, cougar distribution corresponds to that of mule deer (Anderson 1938) and this is partially the case in BNP (Olson 1984). However, elk, sheep and mountain goats are also important prey in BNP (Holroyd and Van Tighem 1983). Occasionally, cougars have preyed on domestic cats and dogs in Banff and Jasper. Every effort should be made to relocate such animals without destroying them since they are extremely rare in the park. Frequent use of the Montane Ecoregion exposes the animals to highway and railroad hazards. Seven have been killed in this way in BNP since 1949. Given their present tenuous status in BNP, even low levels of unnatural mortality and habitat loss may affect the population markedly and account for their present rarity. Fencing of the Trans-Canada Highway along with restoration of ungulate winter range away from the railroad and highway may increase cougar numbers in BNP.

To many, the cougar is symbolic of the wilderness character and ecological integrity of BNP. Retention of this animal, even as a rare species, may ultimately hinge on the preservation of low elevation wilderness (Holroyd and Van Tighem 1983).

Woodland Caribou (*Rangifer tarandus caribou*)

Prior to 1900, viable populations of woodland caribou occurred across Canada from Newfoundland to the southern Yukon Territory and south into Washington, Idaho, Montana, Minnesota, Michigan, Wisconsin, New Hampshire, Vermont and Maine. However, hunting, logging of mature forest and disease eliminated them from the contiguous United States except for a small herd on the boundary of Idaho and British Columbia. Canadian populations were similarly reduced. Currently in Alberta, caribou occur from the Siffleur River valley in BNP, north through the Whitegoat Wilderness Area and JNP to south of Grande Prairie. They also occur north of Peace River to the Northwest Territories and in northeastern Alberta from Cold Lake northward. The southernmost herd is on the Siffleur River in BNP. The Alberta population is presently estimated at fewer than 4000 (Alberta Fish and Wildlife Division 1984), down from 7000 to 9000 in 1966 (Holroyd and Van Tighem 1983).

Woodland caribou are the rarest ungulates in BNP with an estimated current population of 10 to perhaps 15 animals in the Siffleur River area, including Dolomite Pass, Clearwater Pass and the upper Pipestone River. All observations between 1945 and 1976, with one exception, were from the Siffleur watershed. These sightings were for 1972, 1973 and 1974, with a maximum of 12 animals in 1974 (Holroyd and Van Tighem 1983). Since 1975, 27 observations, totalling 99 animals, have been recorded with a maximum single sighting of 14 animals in 1982 and 1985 (Warden Wildlife Files 1977 - 1985) (Fig. 10). There are also observations from the upper North Saskatchewan River and Castleguard River valleys from the 1940's (Jacobson 1979) which are likely from the herd around Job Creek and the Whitegoat Wilderness Area. It is unlikely that the Siffleur herd has contact with any other caribou population and thus is in a precarious situation with regard to both limited genetic diversity and catastrophic mortality.

In JNP, Stelfox *et al.* (1978) found a correlation between summer range and permanent snowfields. They concluded that caribou there are under marginal climatic conditions in summer and that snowbeds allow them to withstand summer heat. Stress from frequent contacts with humans and elk on summer range, and a gradually warming climate may all contribute to the population decline (Stelfox and Bindernagel 1978).

Present caribou distribution in BNP is similar to that of the 19th Century (Holroyd and Van Tighem 1983) which indicates that the Siffleur River watershed has been the southern limit in Alberta for some time. The Siffleur Wilderness Area north of BNP provides additional area to isolate the Siffleur herd from hunting and other disturbance. However, they may be vulnerable if they move out of this area. The present management strategy in BNP of permitting only low levels of recreational use on caribou summer range, of no hunting and of fire suppression in lichen-producing forests (Holroyd and Van Tighem 1983) should be continued. However, the factors currently limiting population size and

Fig. 9 Cougar observations in Banff National Park, 1975-1984.

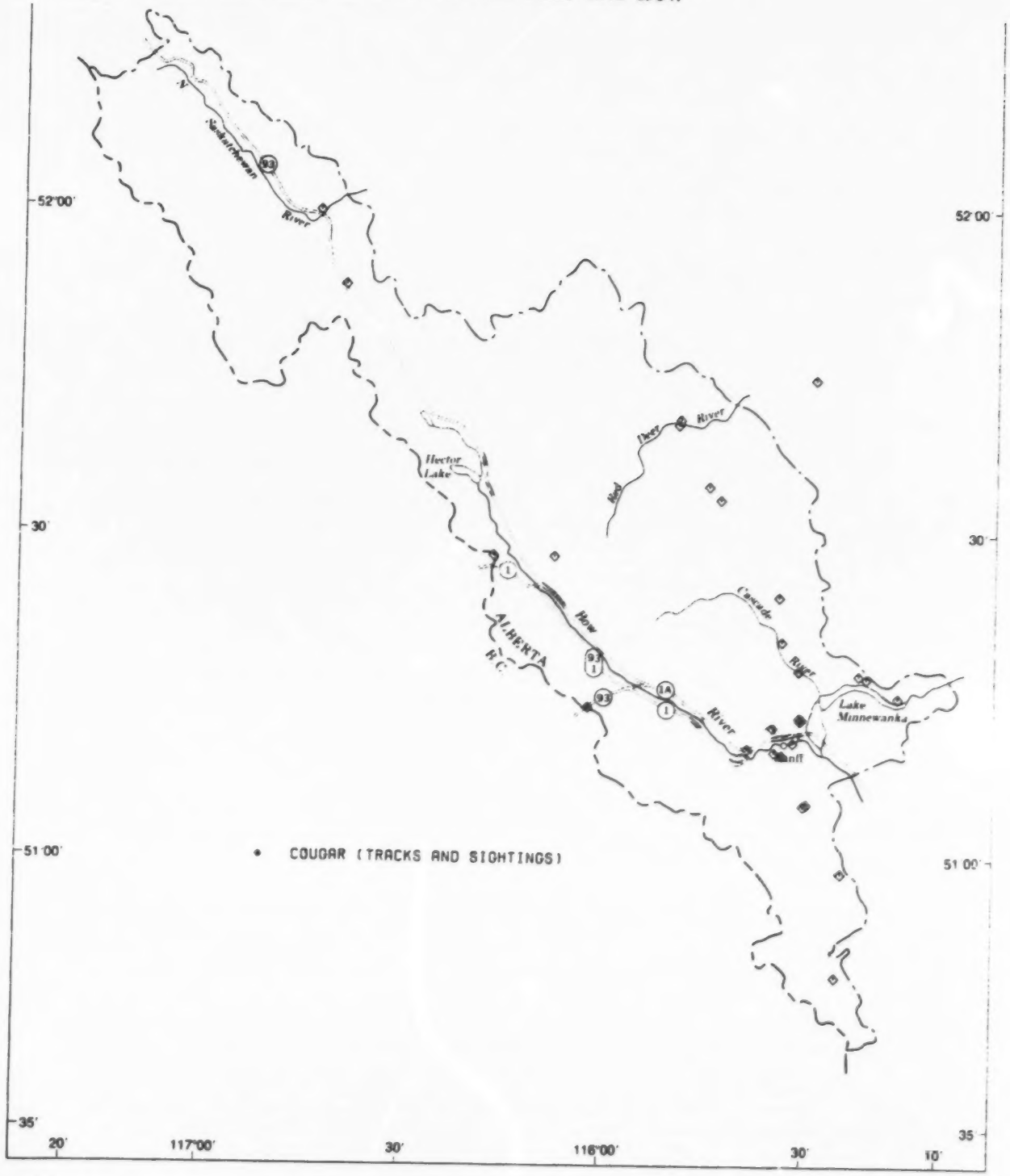
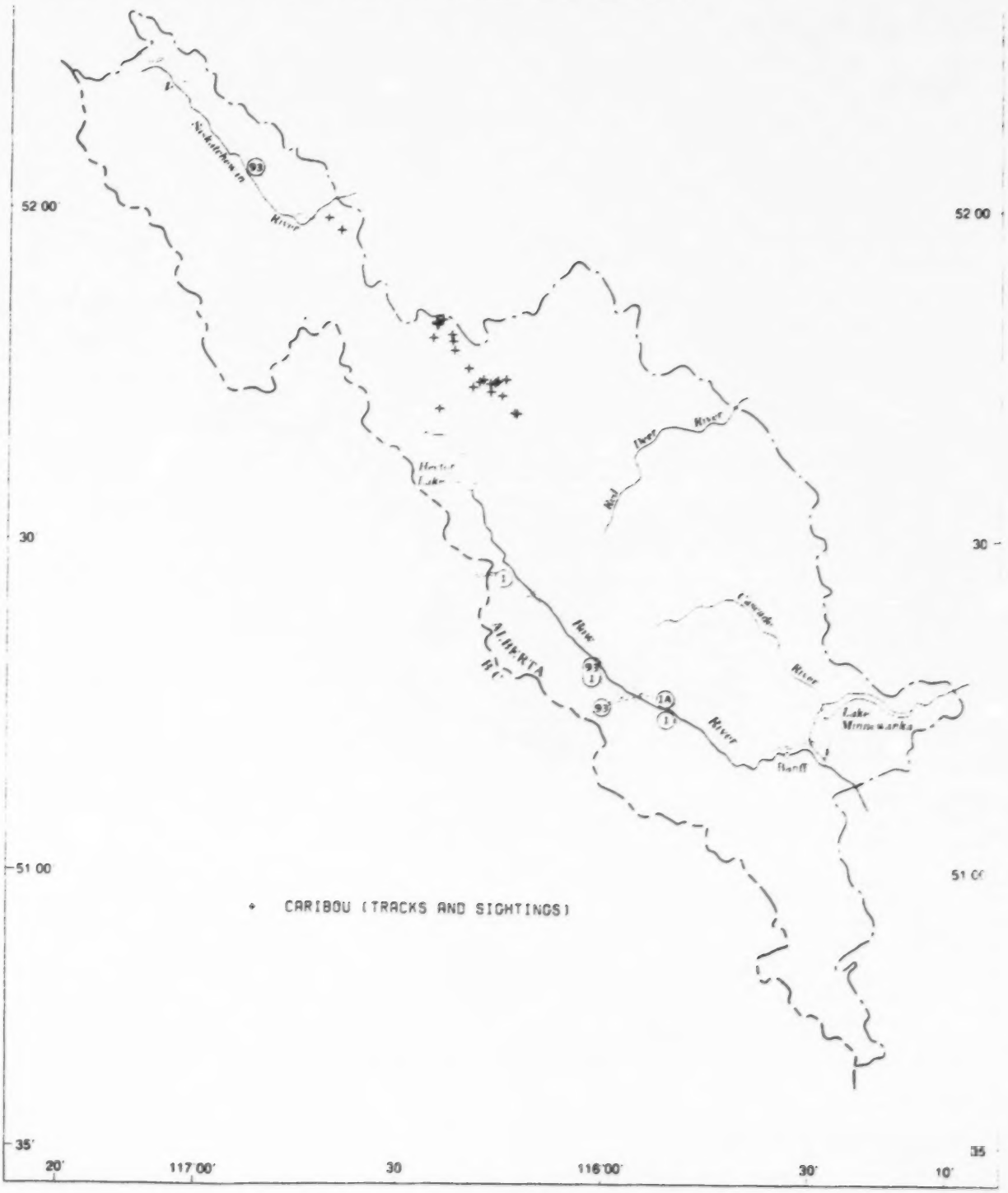


Fig. 10 Caribou observations in Banff National Park, 1975-1984.



distribution are not known and no marked increase in numbers seems likely. Because of the very small number of caribou in BNP, any proposed research program must be thoroughly evaluated to ensure that it does not subject the animals to unacceptable stress levels.

White-tailed Deer (*Odocoileus virginianus*)

Although white-tailed deer are widespread in North America and in the southern half of Alberta, they are the second rarest ungulate in BNP (Holroyd and Van Tighem 1983, Warden Wildlife Files 1945-1976, Warden Wildlife Files 1977-1985). The maximum single herd count of six indicates their scarcity. Peak numbers between the Cascade Power House and Vermilion Lakes are likely fewer than ten animals (Olson 1984). There are currently resident populations in the lower Bow Valley and possibly near Saskatchewan Crossing. Winter numbers are low, 18 animals in the winters of 1977 to 1982, suggesting that their winter range is mostly outside the park. Both summer and winter observations have trended upward during 1983-1984 (Warden Wildlife Files 1977 - 1985) but it is not clear whether this is a real increase due to range expansion or population growth or whether it is due to increased reporting. Thus, while white-tailed deer have increased their numbers and range in most of Alberta, the situation is less clear in the mountains (Holroyd and Van Tighem 1983).

White-tailed deer occur mainly in the Montane and Lower Subalpine Ecoregions, in disturbed habitats (roadsides, gravel pits) and in coniferous forests and shrubby meadows (Warden Wildlife Files 1945-1976, 1977-1985).

Research is needed in BNP to determine whether white-tailed deer winter range exists in the park and to determine migration routes of those animals wintering outside the park. Fencing of the Trans-Canada Highway should reduce highway mortalities of this species.

Wood Bison (*Bison bison athabascae*)

In the early 1800's, there were an estimated 100,000 wood bison in Canada (Soper 1941). However, hunting and possibly disease reduced the numbers rapidly and by 1894 only 150 were left. A remnant population in present-day Wood Buffalo National Park was protected in 1894 and by 1922 had increased to between 1500 and 2000 (Banfield 1974). Introduction of plains bison to Wood Buffalo National Park in the late 1920's nearly made wood bison extinct through disease and hybridization. However, in 1957 a pure wood bison group was found and a breeding program was established at Elk Island National Park. The Canadian Wildlife Service is currently coordinating efforts to establish free-ranging herds in at least five locations to protect this subspecies from disease or catastrophic events. Successful reintroductions to the wild have been made from this stock in the Nahanni area of the Northwest Territories and the Waterhen area of the Interlake region in Manitoba. Additional reintroductions are planned soon for the Hay-Zama lakes area of northwestern Alberta and near Carmacks, Yukon Territory. A reintroduction attempt in 1978 in JNP was unsuccessful. Wood bison are variously an endangered subspecies (COSEWIC 1985) and threatened with extinction (CITES 1984). There are about 1000 wood bison in Canada currently.

Wood bison occurred widely in BNP until the 1850's (Holroyd and Van Tighem 1983). In 1981, five animals from the Elk Island stock were put in the paddock near the airport replacing the plains bison there previously.

Reintroduction of free-ranging wood bison to BNP is not an immediate prospect. More needs to be learned about reintroduction techniques, as the 1978 attempt in JNP showed. Of more immediate concern is the present paddock which is in an undesirable location for two reasons. First, the fenced paddock and other barriers such as the townsite and topographic features form a major obstacle to the migration of wildlife through the Bow Valley near Banff (section 4.3.6). Completion of highway fencing by 1987, will necessitate either removal of a portion of the paddock or complete relocation of the paddock to some other area (Leeson 1984). Secondly, the paddock excludes other ungulates from valuable winter range. Since the bison are fed hay much of the year, the paddock could be relocated to less valuable habitat, making the present area available for free-ranging wildlife. A partial solution may be a 1.2 m fence around the paddock to permit elk and deer to move in and out.

Other Significant Mammals

Muskrat (*Ondatra zibethicus*)

Muskrats have a very restricted distribution in BNP. The densest population is in the Vermilion Lakes area where there were 100 in 1978 (Bow Valley Naturalists 1978). Other recent observations are from Lake Minnewanka, lower Cascade River, Muleshoe, Wigmore Lake, Clearwater Lake (Warden Wildlife Files 1977 - 1985) and Snow Creek Pass (Achuff 1978). From 1945 to 1976, observations were recorded from Vermilion Lakes, Johnson Lake, Banff townsite, Saskatchewan Crossing and the Red Deer River (Sandhills slough) (Warden Wildlife Files 1945 - 1976).

Muskrats inhabit alluvial wetlands with sedge beds and seasonally flooded willow stands as well as the edges of lakes and slow moving streams. Water depths are generally 1.5-3.5 m.

Grizzly Bear (*Ursus arctos*)

Grizzly bears once occupied most of the western half of North America from the Mexican Highlands to the Arctic Ocean (Banfield 1974). Within the last 100 years, grizzly bears have been almost extirpated from Mexico, the contiguous United States and the Canadian prairies. Grizzlies are still common in the northern part of the Canadian cordillera and Alaska, but are becoming increasingly scarce in the southern part of their range in Yellowstone and Glacier national parks in the United States and in the southern Canadian Rockies. Because of the relatively large, undisturbed areas required by grizzly bears, they have become to many a symbol of wilderness integrity (Hamer and Herrero 1983, Pearson 1975).

In Alberta, the current population outside of the national parks is estimated at 500 to 1000 animals (Alberta Fish and Wildlife Division 1984). Numbers in BNP have been estimated at 100 (Clarke 1940), fewer than 100 (Banfield 1958), 55 to 85 (Vroom 1974), and 55 to 80 (Holroyd and Van Tighem 1983). Perhaps as many as 160 bears use the park although fewer are full-time residents (Kunelius 1986). Grizzly bear density in BNP has been estimated at one bear per 78 to 120.5 sq km (Vroom 1974), which is similar to the density in JNP (Russell *et al.* 1979). These densities are characteristic of populations in the Alberta Rockies (Hamer and Herrero 1983) but are low compared to many other parts of the current range (Russell *et al.* 1979). This low density increases the vulnerability of the bears to mortality, habitat loss and disturbance by recreation and facility development (Russell *et al.* 1979).

The primary areas of grizzly bear abundance in BNP (Fig. 11) are:

1. the Cascade Fire Road between Stoney Creek and Snow Creek Pass, including the valleys on either side and the lower Panther River (Hamer and Herrero 1983)

2. the Flints Park area, including the north fork of the Cascade River, Sawback Lake and Sawback Creek (Vroom 1977)

3. the Skoki area, including Baker Lake, Red Deer Lakes and the Little Pipestone River (Jacobson 1986)

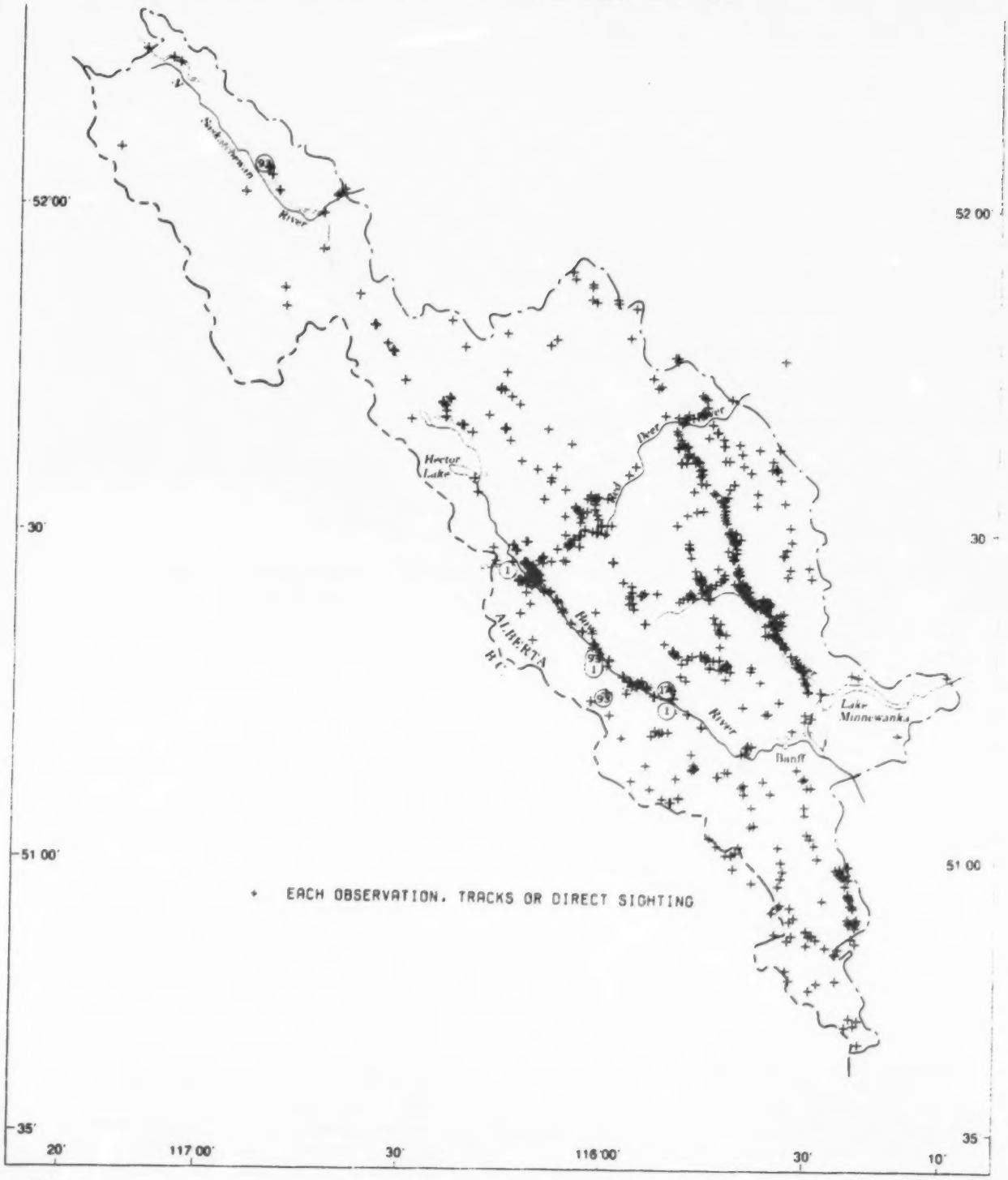
Secondary areas of abundance include: upper Johnston Creek, Mystic Pass, Pipestone Pass and the lower Spray River between Sixteenmile and Fortune cabins.

Grizzly bears were formerly more abundant in the Egypt Lake area (Brewster Creek to Redearth Creek), upper Bryant Creek and the upper Spray River valley (Noble 1972). Heavy hunting in adjacent parts of British Columbia, especially the Mitchell River valley, between 1940 and 1970 is thought to be a major factor in the decline (Noble 1972). During the nineteenth century, grizzly bears were abundant around Bow Pass and along the Mistaya River and North Saskatchewan River. However, hunting prior to 1930 and construction of the Banff-Jasper highway in 1931 to 1940 probably adversely affected these animals (Noble 1972).

Mating and denning areas have been identified for the Front Ranges in BNP (Hamer and Herrero 1983, Vroom 1975, Vroom *et al.* 1980, Warden Wildlife Files 1977-1985) but are not well known for the rest of the park.

Although grizzly bears are not an endangered species in Canada, the great reduction in range and numbers is cause for concern. The species has not coexisted well with human activity generally and the BNP populations are near the current edge of the species' range. While the national parks provide a major sanctuary for grizzlies in the Rocky Mountains, increasingly intensive use of both parks and adjacent lands for recreational and resource exploitation activities is putting increasing pressures on the

Fig. 11 Grizzly bear observations in Banff National Park, 1975-1984.



grizzlies in BNP. Preservation strategies for grizzlies must include measures dealing with both habitat and human activities. The key factors (Hamer and Herrero 1983) include:

1. recognition of important bear habitats and control of human use of these areas to maximize separation of bears and people

2. removal of all garbage and artificial attractions that lure bears into areas where they become conditioned to coexisting with people at close quarters

3. preservation of high quality, fire-dependent habitat in remote areas by returning to unsuppressed wildfires or prescribed burning.

These objectives can largely be achieved by continued implementation of the Interim Wildland Fire Management Plan (White 1984), the Bear Management Plan (Westhaver 1982) and the Bear Activity Information System (Kunelius and Buckley 1982).

Moose in the Bow Valley (east gate to Lake Louise)

From the reports of early travellers and explorers in the Rocky Mountains, it appears that moose (*Alces alces*) were widely distributed and sufficiently abundant to be a major meat source in the nineteenth century (Holroyd and Van Tighem 1983). However, by the early part of this century, moose were nearly extirpated in the Rocky Mountains of Alberta, probably because of overhunting, habitat loss and possibly disease (Soper 1970). After this decline, the first moose in the Bow Valley was seen between Redearth Creek and Altrude Creek in 1931 (Green 1955b). Moose became extremely abundant in the 1930's to 1950's (Green 1955c). By the 1960's, the population had begun to decline (Olson 1984), although as recently as February 1972, 30 were in the Vermilion Lakes area (Holroyd and Van Tighem 1983). Moose in the Bow Valley are difficult to census because of seasonal movements into adjacent tributary valleys. Only 30-50% of the moose wintering in the Bow Valley are resident year round (Brown 1986, Harrison *et al.* 1982).

The decline in the lower and middle Bow Valley numbers has been attributed to both collisions with highway vehicles and trains (Holroyd and Van Tighem 1983) and to habitat loss. The mortality due to collisions alone from 1978 to 1985 was roughly 3-4 animals/year, while the population has been estimated to be capable of sustaining a total mortality of around 1.5-3.75/year (Flygare 1978, Harrison *et al.* 1982, Holroyd 1979, Warden Wildlife Files 1977-1985). Thus, the moose population in the Bow Valley is in a very delicate situation with unnatural mortality being frequently close to or exceeding the rate which the population can sustain.

A reduction in highway mortality is unlikely unless the proposed Phase III twinning of the Trans-Canada Highway from Sunshine Junction to Castle Junction includes fences and underpasses. The effectiveness of the underpasses for moose is not clear (Olson 1984). Mortality rates may rise from increased railroad traffic and increased natural predation from the recent winter influx of wolves into the Bow Valley (Warden Wildlife Files 1977-1985).

Moose are heavily dependent on vegetation in the early stages of succession following disturbance by fire, fluvial action or avalanche. The policy of complete fire supression has decreased both the quality and quantity of moose habitat as shrubby habitats have succeeded to more mature forest. This may have concentrated the animals more in valley bottoms where processes other than fire provide favorable habitats, but also where railroad and highway mortalities are greater. Moose would benefit from a fire management policy which would create a greater mix of habitats in various successional stages.

4.3 Ecologically Important Habitats

The habitat of a species consists of the resources and areas needed during various periods of the year to complete its life cycle. Some species, which are not rare or of restricted distribution, nevertheless have portions of their annual habitat requirement that are restricted in distribution or amount, or that are threatened by human activities. These key areas are termed ***ecologically important habitats*** here and include: ungulate mineral licks, elk, sheep, goat and deer seasonal ranges, wildlife migration corridors, waterfowl staging and nesting areas, Dipper wintering areas and black bear den areas.

4.3.1 Mineral Licks

All ungulates use earth licks, however there is no consensus on what elements are sought or what physiological needs are fulfilled. A comparative study of ungulate licks throughout North America concludes that in western North America, calcium and magnesium are the important elements gained from licks while in eastern North America, sodium and magnesium are important (Jones and Hanson 1985). Magnesium and sodium seem to be required to balance potassium gained from lush, spring vegetation, while calcium seems needed for bone growth and to replace that lost by females during pregnancy and lactation.

In BNP, licks are predominantly used during May - June by elk, and June - July by goats. Peak use of mineral licks by bighorn rams is in May while ewes visit licks throughout the summer. Various studies relate this use in goats, sheep and elk to calcium deficiencies caused by pregnancy, lactation and bone growth coupled with reduced calcium levels in lush vegetation and to copper deficiencies due to molting and hair regrowth (Dalke *et al.* 1965; McCrory 1965,1967). Lick use has also been correlated with sodium concentrations and the increased loss of sodium which accompanies the dietary change to spring vegetation (Hebert and Cowan 1970). Lick use by sheep in BNP in June and July occurs during lambing and shedding which result in a need for copper, calcium and phosphorus (Stelfox 1976). In addition to a nutrient balance function, lick use may be involved in the alteration of intestinal flora and fauna (Cowan and Brink 1949) and in the reduction of parasite loads (McCrory 1965).

Currently, 82 natural earth licks are known in BNP (Table 3) and their distribution corresponds with areas of greatest ungulate population (Fig. 12). Analyses of some licks have been done (Cowan and Brink 1949, Jacobson 1986, Jones and Hanson 1985) but comparisons are difficult due to differing analytic methods.

Licks have a large influence on ungulate distribution and movement particularly during the spring when lick use is greatest. Because licks concentrate animals at certain times, knowledge of their locations can assist in monitoring these populations. Additional documentation of lick location and use would help in this regard.

4.3.2 Elk Seasonal Ranges

In BNP, elk (*Cervus elaphus*) use a variety of habitats throughout the year (Skjonsberg 1985a) and make major migrations between seasonal habitats (Morgantini and Hudson 1983). The critical habitats of limited areal extent discussed here are fall ranges, winter ranges and the Bow Valley calving ranges.

Fall Ranges

The movement to fall ranges begins in September, usually in response to significant snow fall. Except for temporary returns to higher, summer ranges during good weather, elk use the fall ranges until movement to winter ranges, usually after 15 November (Morgantini 1984). Fall ranges include the Bow Valley from Lake Louise to the east gate and a number of areas on the Front Ranges. Along the eastern boundary of BNP, movement to winter ranges outside the park may be delayed due to hunting (Morgantini and Hudson 1983). Herd sizes in the Front Range areas (Fig. 13) are estimated (Skjonsberg 1985b) as:

Spray Sixteenmile Range	100
Palliser Range	200
Lower Panther River	200
Bare Mountain	100
Lower Red Deer River	400
Indianhead Creek	100

Fall elk ranges, although limited, are not presently impacted by human activities, except in the Bow Valley. Horse grazing in the lower Red Deer River may reduce forage but whether this is significant is not known. The need for a grazing study has been identified (Parks Canada 1985) and this area would be part of such a study.

Fig. 12. Wildlife mineral licks in Banff National Park, 1975-1984.

Fig. 13 Fall elk ranges in Banff National Park, 1975-1984.

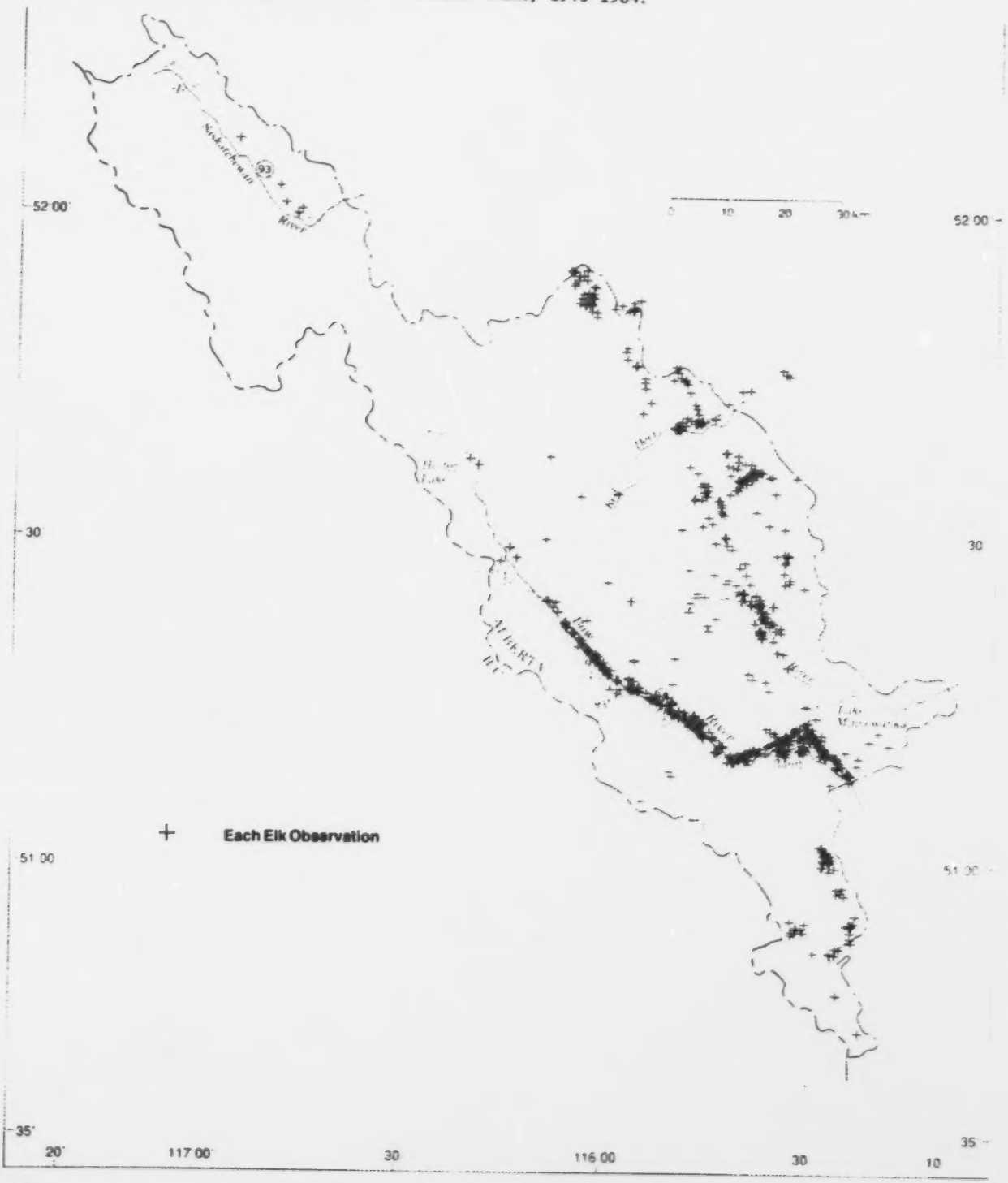


Table 3. Natural mineral licks used by ungulates in Banff National Park. Species: C = caribou, D = deer, E = elk, G = mountain goat, M = moose, S = bighorn sheep.

Watershed	UTM	Location	Species
Bryant Creek	PG018442	Allenby Ck.	E
Bow River	PG159729	Carrot Ck.	E
	NG975706	Vermilion Lakes	S
	NG962631	Mt. Bourgeau	S
	NG847641	Healy cabin	S
	NG957702	Vermilion Lakes	S
	NG862631	Sunshine Rd.	S
	NG985709	Vermilion Lakes	D,M,S
Cascade River	NG865960	Flints Park	G
	NG870965	Flints Park	G
	NG874966	Flints Park	G
	NG878978	Flints Park	E,G,S
	NG883985	Cuthead Ridge	S
	NG884971	Cuthead Ridge	D
	NG890965	Flints Park	E
	NG950879	Stony Ck.	E
	NG965912	Cascade R.	E
	NG921945	Grassy Mtn.	E
	PG023827	Cascade R.	S
	PG017988	Dormer Pass	—
Cuthead Creek	NG885981	Cuthead Ridge	E
	NG910989	Cuthead Ridge	E
	NH876013	Cuthead L.	E
	NH935007	Bighorn L.	S
Divide Creek	NH751314	South Basin	E
	NH729315	Middle Basin	—
	NH722327	North Basin	—
Dolomite Creek	NH404400	Isabella L.	—
	NH358346	Silverhorn Mtn.	C
Dormer River	NH988008	Dormer Pass	G,S
	NH985028	Dormer Plateau	E,S
	PH013027	Dormer R.	E,G,S
Indianhead Creek	NH621501	Indianhead Ck.	—
	NH692439	Clearwater R.	M
L. Minnewanka	PG058780	bridge	S
	PG087838	Aylmer Lookout	S
	PG130815	Aylmer Canyon	—
	PG023760	Minnewanka Rd.	S
Mistaya River	NH321344	Icefields Pky.	—
North Saskatchewan River	NH129522	Glacier Ck.	—
	NH160555	old cabin	—
	NH170562	Howse R.	—
	MH913713	Terrace Ck.	—
	NH199576	warden pasture	M
Panther River	NH309079	north fork	E
	NH845119	Harrison L.	E
	NH865039	Wigmore Ck.	E

Watershed	UTM	Location	Species
	NH862091	Panther R.	E
	NH853123	Harrison L.	E
	NH858129	Snow Ck.	E
	NH862068	Sheepshead Ck.	E
	NH874077	Sheepshead Ck.	E
	NH886198	Gable Mtn.	E
	NH883050	Sheepshead Ck.	E,M
	NH903155	w. shortcut	—
	NH932163	e. shortcut	—
	NH970160	Barrier trail	—
	NH945155	Panther R.	D,E,M
Peters Creek	NH716407	Peters Ck.	—
Pipestone River	NH569076	Pipestone R.	—
	NH575028	Whitehorn Mtn.	—
	NH581092	Point Camp	—
Red Deer River	NH749228	Prow Mtn.	—
	NH760234	McConnell Ck.	S
	NH793249	Divide jx.	—
	NH794193	Pipit L.	—
	NH798324	Tyrrell Ck.	—
	NH810195	Prow Mtn.	E
	NH828245	Mt. Tyrrell	S
	NH843253	Tyrrell Ck.	E
Redearth Creek	NG792607	Lost Horse Ck.	E,G
	NG794658	Lost Horse Ck.	E,G
	NG803638	Lost Horse Ck.	E,G
	NG725708	Gibbon Pass	G
	NG778663	Mt. Ball	G
Siffleur River	NH405422	Siffleur R.	—
	NH455331	Mt. Kentigern	E
	NH488302	Clearwater Pass	S
Spray River	PG039606	Eightmile	S,G
	PG084519	16mile Range	E,S
	PG035603	Eightmile	G
	PG052621	Goat Ck.	G

Forest encroachment on natural grasslands in BNP has been reported by numerous researchers (Green 1957, Hamer and Herrero 1983, Stelfox 1970) but has not been quantified to date. Although prescribed burning in backcountry areas is under consideration, such a policy on most of these ranges must consider the proximity of forests outside the park and thus is not likely to be implemented in the near future.

Winter Ranges

The extent and quality of winter range is the major limiting factor on elk numbers in BNP (Morgantini 1978, Skjonsberg 1985a). Elk are primarily grazers and thus, snow depth significantly influences their numbers and distribution (Bobek *et al.* 1979). Of the 2400 elk that summer in BNP, only 1100 remain year round, about 300 use winter ranges on both sides of the eastern park boundary and 1000 depend entirely on winter ranges outside the park (Skjonsberg 1985a). In considering the major winter ranges and estimated numbers of elk presently using them (Table 4), the Bow Valley is by far the most important winter range in BNP (Skjonsberg 1985a). The most critical and important parts of the Bow

Table 4. Elk winter ranges and numbers in BNP and adjacent provincial lands (Skjonsberg 1985a).

Range	Number	Location
Bow Valley	900	BNP
Ya Ha Tinda	450	prov.
Scotch Camp-Tyrrell Ck.	100	BNP-prov.
Panther Corners	350	prov.
Panther River	100	BNP-prov.
Palliser Range	100	BNP
misc. pockets	50	BNP
Harrison Flats	150	prov.
Ram River	50	prov.
Spray Sixteenmile	80	BNP
Kananaskis	40	prov.
Siffleur River	50	BNP-prov.
Baker Creek	50	BNP
N. Saskatchewan R.	50	BNP-prov.

Valley winter range (Brown 1986, Harrison *et al.* 1982, Holroyd and Van Tighem 1983, Jacobson 1981, Kunelius 1986, Olson 1984) are:

1. the Banff Springs golf course and adjacent meadows and closed pine forests

2. the Tunnel Mountain Campground area and the west slopes of Tunnel Mountain

3. the Indian Grounds and Banff airfield area, including the closed spruce forests along Whiskey Creek and the Fortymile Swamp area

4. Hillsdale meadows, 17 Mile Flats, Castle and Silver City meadows along the Bow Valley Parkway

5. the Vermilion Lakes area south of the railroad tracks from First Vermilion Lake to the confluence of Healy Creek and the Bow River

6. the Muleshoe backswamp area east to the Fivemile bridge and south to the Sunshine junction

7. from the east gate to the Minnewanka interchange, including the river flats near Carrot Creek and the benchlands north of the highway

8. revegetated gravel pits near Redearth Creek.

9. south-facing slopes from the Sawback picnic area west to Johnston Creek.

Elk numbers in winter between the east gate and Castle Junction have increased from 437 in 1980-1981 (Harrison *et al.* 1982) to 800-1000 in 1985-1986 (Kunelius 1986). Highway fencing will reduce both mortality and available range (Olson 1984). The reduction of access to range immediately adjacent to the highway will likely have a significant effect (Olson 1984). Since factors such as disease and winter severity also influence elk numbers, the future trend of population size is not clear.

The principal threat to the Bow Valley winter range is the incremental loss of habitat. Continued development of transportation corridors and visitor facilities, such as fencing of the Trans-Canada Highway, will remove additional critical habitat. Infilling of the townsite will further encroach on wildlife migration corridors. Developments of this sort must be carefully evaluated by the Environmental Assessment and Review Process.

The second most important winter range is the Ya Ha Tinda area. This area supports one of the most important herds in Alberta (Morgantini and Hudson 1983). Winter counts are up to 1000 (Le Blanc 1985) but are more commonly 350-450 (Morgantini 1984).

Continued fire suppression diminishes the extent and quality of winter ranges throughout the park. Prescribed burning can lessen this trend and restore both the amount and quality of winter range.

Lower Bow Valley Calving Ranges

A number of traditional calving grounds have been identified in the lower Bow Valley (Holroyd and Van Tighem 1983, Jacobson 1981, Olson 1984) including: undeveloped areas of the Banff Springs golf course, islands in the Bow River from the golf course to the east gate, and along the Bow River and the horse stable marsh. Presently, these areas are affected to some degree by recreation, such as canoeing, hiking and photography. Completion of the Wolf Street bridge over the Bow River, golf course expansion, and the new trail to Canmore may further disturb elk on these ranges. Further development of the area between the Bow River and the Cave Avenue-Sundance Canyon road and in the wooded areas at the north and east ends of the golf course should be avoided The effect of this continued loss of important calving range cannot be estimated currently, but monitoring of calving should continue to determine possible effects.

4.3.3 Sheep Seasonal Ranges

Bighorn sheep (*Ovis canadensis canadensis*), in the Canadian Rocky Mountains occur mainly in the East Slopes between 51°N and 55°N and on both slopes south of 51°N (Stelfox 1971). In BNP, as in other parts of Canada, bighorn sheep populations have fluctuated in the last century (Stelfox 1971). Presently, they occupy all of their historic range plus some additional areas (Stelfox 1970). Since sheep traditionally use the same ranges, these areas are useful for monitoring and also attract park visitors interested in viewing wild sheep.

This section includes both seasonal ranges of limited extent which are critical to sheep and areas with an exceptional number of animals which are considered ecologically important habitats. These are winter ranges and major summer-early fall ranges.

Sheep Winter Range

Sheep winter range in BNP is largely restricted to southerly aspects with windswept grasslands and adjacent escape terrain, and comprises about 10% of the area of the summer range (Fig. 14) (Stelfox 1970). The extent of winter range varies annually depending on snow depth and hardness (Stelfox 1976, 1978). Its extent in the long term varies depending on fire frequency and forest succession (Stelfox 1970, Green 1949). Fire supression since 1940 may have significantly modified the vegetation of some areas (Hamer and Herrero 1983, White 1985a) and the genesis of the Spray Sixteenmile and Palliser winter ranges is likely directly related to fire (White 1985b). A comparison of winter sheep numbers (Table 5) with fall counts shows that 20% to 30% winter outside the park (Skjonsberg 1985a).

Only the Bourgeau and Vermilion Lakes winter ranges are presently impacted by human activities. Sheep from the Bourgeau herd have been caught in artificially triggered avalanches but this is uncommon and this unnatural mortality might be offset somewhat by the creation and maintenance of additional habitat by avalanches (Jacobson 1981). Mortalities from collisions on the road while the sheep are licking road salt are more frequent than avalanche mortalities but are not a major influence on population levels. The Vermilion Lakes-Sawback herd declined from 300-400 sheep in the late 1940's (Green 1949) to a low of about 120 (Harrison *et al.* 1982). Highway mortality and habitat loss were likely the primary causes. From 1965 to 1975, 83 highway deaths were recorded (Flygare 1976) and between 1976 and 1985 another 69 deaths were known (Warden Wildlife Files 1977 - 1985). In addition, 26 animals from this herd were trapped and relocated in 1969-70. The herd is presently estimated at 150 sheep (Skjonsberg 1985a).

Fencing and underpasses along the twinned sections of the Trans-Canada Highway, to be completed in 1986, should reduce highway mortalities in the Vermilion-Sawback herd. A study of this herd, scheduled for 1986 will assess population structure, habitat use and movement. The Sunshine road should be signed to warn visitors of sheep from the Bourgeau herd on the road. Additional signs concerning speed limits and to deter feeding may also help prevent collisions (Harvey *et al.* 1985). Recommendations for joint management with Alberta Fish and Wildlife of sheep which range east of the park boundary will be in the final East Slopes Wildlife Report, to be completed by May 1987

Fig. 14 Winter (Dec - Mar) bighorn sheep observations in Banff National Park, 1975-1984.

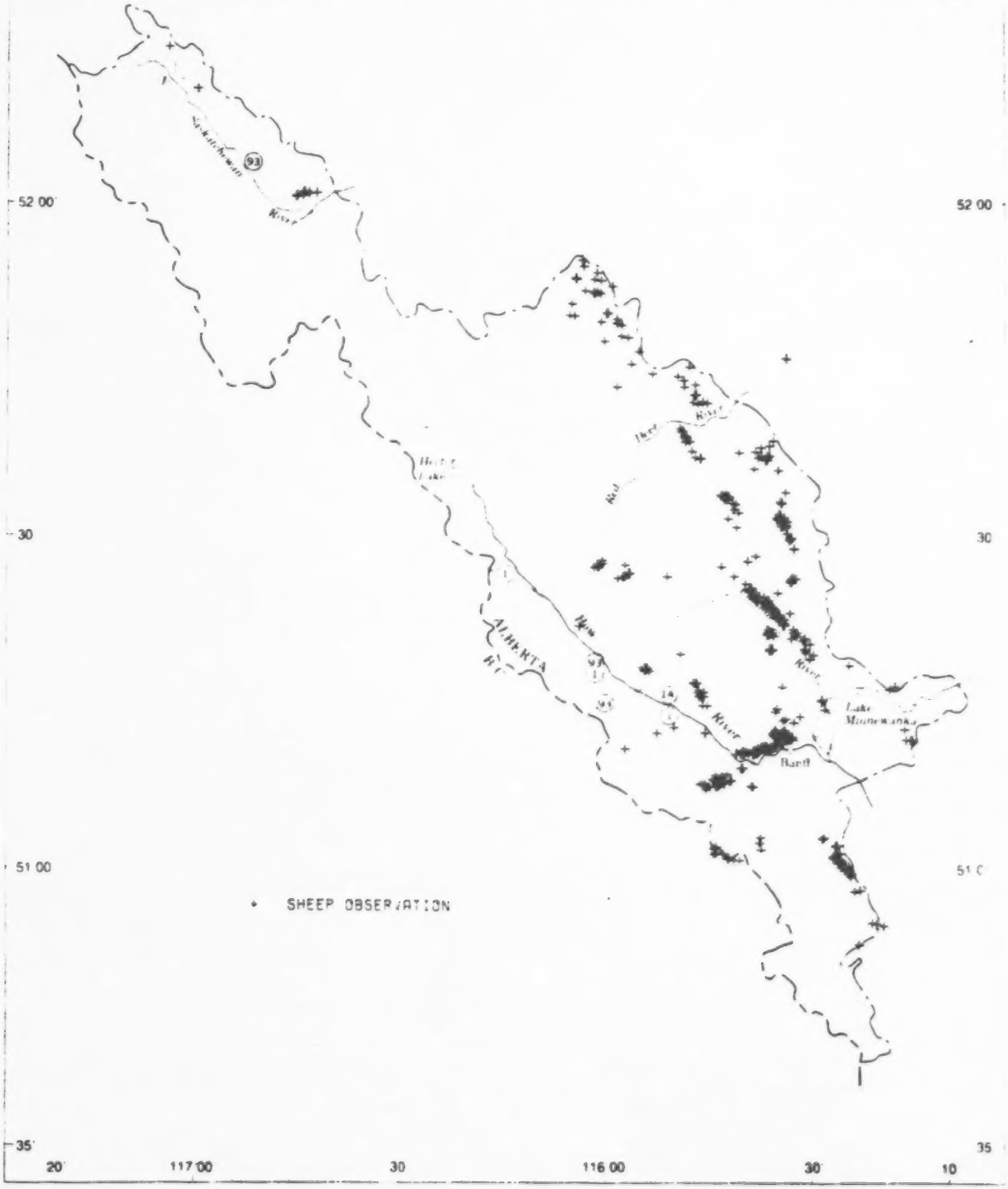


Table 5. Bighorn sheep winter ranges and populations, March 1985 (Skjonsberg 1985a).

Range	Number
Mount Nestor	13
Spray Sixteenmile	48
Fatigue Mountain	13
Quartz Ridge-Citadel Pass	45
Mount Bourgeau	84
Sundance Range	17
Vermilion Lakes	30
Sawback Range	120
Castle Mountain	22
Baker Creek	35
Carrot Creek	47
Mount Costigan	65
Mt. Inglismaldie-Mt. Girouard	14
Cascade road (5-7 mile)	3
Cascade Mountain	57
Palliser Range	59
Grassy Mtn.-Cabin Mtn.	51
Flints-Cuthead-Wigmore	3
Dormer Pass-Stoney Ck.	30
Dormer Plateau	139
lower Dormer R.	28
Panther Mtn. west	20
Panther sulphur spgs.	29
Barrier Mountain	61
Bare Range-Mt. White	37
Tyrrell Creek	64
Mount Peters	52
Indianhead-Malloch cks.	37
Mount Wilson	46

(Skjonsberg 1985b).

Stelfox (1971) noted numerous factors which he considered to indicate an imminent decline of the sheep population in BNP. In 1970, the winter population of 1250 sheep was considered similar to that prior to the die-off of 1941 to 1948 (Stelfox 1970). The winter population in March 1985 was at least 1214 and estimated at 1335 animals. Thus, the winter population seems relatively stable over the past 15 years, although deterioration in winter range condition might trigger another rapid population decline.

Major Summer-Fall Sheep Ranges

Major ranges are those with a population >75 sheep during the 1984 and 1985 fall counts. These ranges, with the fall 1985 counts (Skjonsberg 1985a), are:

Bourgeau	94
Carrot Creek	125
Sawback-Vermilion	150
Mt. Aylmer-Mt. Costigan	79
Cascade Mountain	75
Palliser Range	146
Dormer Pass and Dormer Plateau	143
lower Panther River	160
upper Panther R.-Bare Mt.	88
Tyrrell and Divide creeks	102
Mount Peters-Peters Creek	131
Indianhead-Malloch creeks	234
Mount Wilson	83

During the summer and early fall, BNP appears to have a high proportion of rams. The ram/ewe ratio during the summer is 60/40 but this drops to 50/50 after the hunting season ends in late fall on adjacent provincial lands and the rams leave the park (Skjonsberg 1985a).

4.3.4 Deer Seasonal Ranges

During the summer, mule deer (*Odocoileus hemionus*) are common throughout the backcountry of BNP occurring at all elevations, while white-tailed deer (*Odocoileus virginianus*) are rare, inhabiting Montane and Lower Subalpine valleys, particularly in the Front Ranges (Holroyd and Van Tighem 1983) (Fig. 15). During the winter, both species move to relatively snow-free lower valleys by migrating eastward out of the park or by moving down to the Montane portions of the Bow Valley or North Saskatchewan River valley (Warden Wildlife Files 1977 - 1985). Both species are largely dependent on the lower Bow Valley during the winter (Fig. 16). Within the lower Bow Valley, important areas (Brown 1986, Olson 1984) include:

1. south-facing slopes from Lake Minnewanka to the Third Vermilion Lake, including the area along the Mount Norquay road

2. the Banff townsite perimeter and forested areas including the lower north-facing slopes of Sulphur Mountain

3. Tunnel Mountain and the benchlands from the Hoodoos trail north to Whiskey Creek

4. the roadside and south-facing benchlands from Johnson Lake to the Cadet Camp

5. near the Bow Valley Parkway junction, west of Banff townsite

6. from Wolverine Creek to Sunshine junction on the Trans-Canada Highway and Fivemile Spring on the Bow Valley Parkway

7. the lower slopes of Mount Cory and Cascade Mountain.

There is a high degree of overlap between winter deer distribution and facility development partly because deer are opportunistic, feeding on the regenerating vegetation of disturbed sites and partly because deer and developers both favor open, south and west aspects (Holroyd and Van Tighem 1983).

Deer in the lower Bow Valley have been estimated at 67 to 80 mule deer and <20 white-tailed deer between the east gate and Sunshine junction (Harrison *et al.* 1982). However, a more recent estimate, based on underpass use, indicates a higher population than this (Brown and Wackerle 1985). Past levels of unnatural mortality probably have exceeded what the population could sustain (Harrison *et al.* 1982, Holroyd and Van Tighem 1983). From 1964 to 1977, 241 mule deer and 15 white-tailed deer were killed on BNP highways (Flygare 1978), and in 1980-1981, 67 mule deer and 15 white-tailed deer were killed between the east gate and Castle Junction (Harrison *et al.* 1982).

Reduced highway mortality is expected when highway fencing is completed, since deer have already shown a high acceptance of underpasses (Brown and Wackerle 1985). Mortality on unfenced sections of the railroad is not significant, with a total of six deaths in 16 years of record.

Recent deer population estimates are not very accurate (Brown and Wackerle 1985, Harrison *et al.* 1982, Holroyd and Van Tighem 1983, Olson 1984), and very little is known of rutting and fawning areas, particularly in the vicinity of Banff townsite (Olson 1984). Thus, further research is needed on population size, dynamics and seasonal movements of both species of deer.

4.3.5 Goat Winter Range

Mountain goats (*Oreamnos americanus*) occur only in northwestern North America in mountains from southeastern Alaska to southcentral Washington and south to central Idaho in the Rocky Mountains (Johnson 1977). In winter, goats occupy a small part of their total range where sun, wind and avalanches keep small areas relatively snow-free for foraging. Where wind-blown slopes and ridgetops provide larger snow-free patches, groups may be three to nine animals. Group size may increase during winters with deeper snow (Petocz 1973, Smith 1977). Where winter habitat is mostly cliff terrain, group size tends to decrease and the amount of range occupied increases, particularly in severe winters

Fig. 15 Summer deer observations in Banff National Park, 1975-1984.

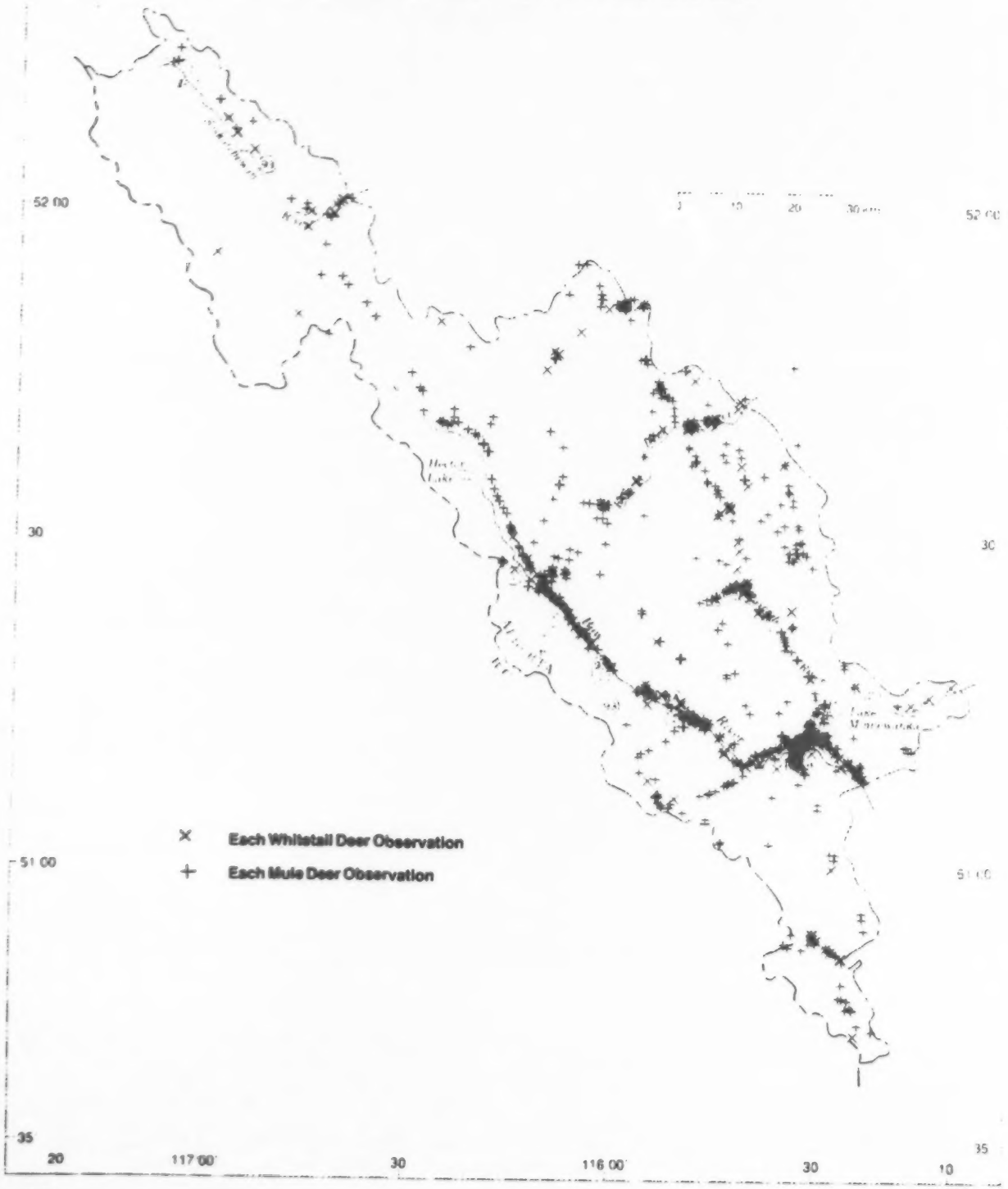
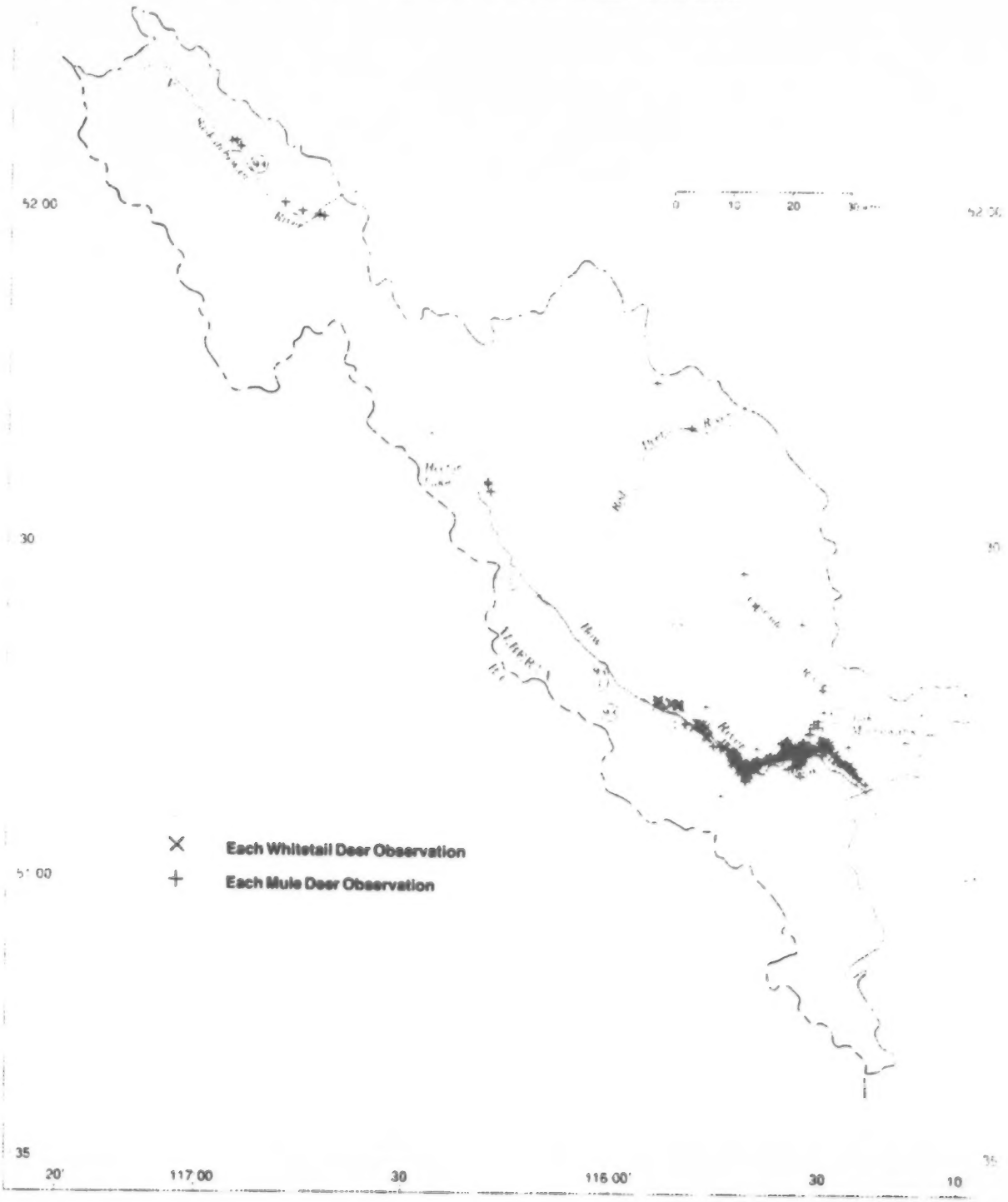


Fig. 16 Winter deer observations in Banff National Park, 1975-1984.



(Chadwick 1983, Jacobson and Loewen 1980, Smith 1977). Both types of winter range occur in BNP (Jacobson and Loewen 1980, Petocz 1973).

A few goats usually occur on every mountain massif in the park during the winter, however they are more numerous in the Front Ranges than in the Main Ranges (Holroyd and Van Tighem 1983) (Fig. 17).

Avalanche control may affect the wintering herds on Mount Wilson, Mount Coleman, Cirrus Mountain and on Parker Ridge (Jacobson 1976), which total an estimated 100 to 150 goats. The Mount Bourgeau population may be similarly affected (Holroyd and Van Tighem 1983). In the Lake Louise ski area, goats have abandoned winter range because of avalanche control blasting (Jacobson and Loewen 1980). It is not presently feasible to alter these avalanche control operations for the benefit of the goats. Goats are also susceptible to aircraft harassment (Jacobson 1976, McFetridge 1977) particularly during the late winter and early spring when energy reserves are low (Holroyd and Van Tighem 1983). Goats are presently monitored every third year during November which should minimize this disturbance. Implementation of the BNP Wildlife Monitoring Plan (Jacobson and Kunelius 1983) should identify long-term trends in goat numbers and habitat utilization. No other management appears necessary to protect winter ranges at the present time.

4.3.6 Wildlife Migration Corridors

Banff townsite lies in a naturally constricted portion of the lower Bow Valley near the junction of several large valleys. Many ungulates, especially elk, must travel through or around the townsite to reach seasonal ranges. This brings many animals close to the townsite and provides opportunities for viewing free-roaming wildlife at close hand which clearly sets Banff apart from other urban centres. However, the travel corridors used by these migrating animals have been further restricted by the numerous man-made barriers of the townsite. In 1982, concerns about the impact of further townsite development resulted in a moratorium on townsite expansion until an Initial Environmental Evaluation was done (Parks Canada 1984). Part of this evaluation deals with the barriers to animal movements created by development. The Initial Environmental Evaluation is now complete and will be released soon (Leeson 1985).

The most constricted part of the Bow Valley runs from Stoney Squaw Mountain to Tunnel Mountain and to the base of Mount Rundle, about 3.9 km. Of this distance, 2.0 km is completely inaccessible to ungulates and a further 0.7 km is a difficult barrier. The remaining 1.2 km consists of four distinct travel routes (Fig. 18):

1. the lower slopes of Mount Norquay and Stoney Squaw Mountain, and the Trans-Canada Highway right-of-way south to Fortymile Creek

2. the railroad right-of-way between the industrial compound and Banff townsite, Whiskey Creek and the grasslands of the Indian Grounds area

3. the lower slopes of Sulphur Mountain, the Banff Springs golf course, and between Mount Rundle and the Bow River

4. the west side of Tunnel Mountain between Banff townsite and the cliffs on the north side

Widening of the Trans-Canada Highway has further narrowed the most northerly route recently. The highway fencing has not been done yet but will further constrict this corridor. Mitigative measures have been recommended (Olson 1984) to facilitate movement along this northern route. These include relocating the bison paddock and terracing a path along Stoney Squaw Mountain to permit easier movement along the widened Trans-Canada Highway and facilitate use of the wildlife underpass near the paddock.

Removal of the golf course fence has also been recommended to improve the Sulphur Mountain - golf course corridor (Olson 1984). This has been begun but is not yet complete.

Further efforts are needed to identify the major and minor wildlife corridors around the townsite and to ensure that managers and planners are aware of their location and importance. The major migration corridors should be zoned appropriately, perhaps Zone III (Natural Environment), to ensure that incremental development does not create further barriers to wildlife movement in this area. Additional

Fig. 17 Winter mountain goat observations in Banff National Park, 1975-1984.

Fig. 18. Wildlife migration corridors near Banff townsite.

mitigative measures in the migration corridors, such as replanting trees near the Pearl Laundry to widen the railroad - Whiskey Creek corridor or removal of the picnic shelter at the Indian Grounds, should continue.

4.3.7 Waterfowl Staging Areas

BNP is part of a flyway for waterfowl that breed in the Grande Prairie-Peace River, foothills and aspen parkland areas of Alberta (Weaver *et al.* 1979). These birds migrate from Alberta to the lower Columbia River valley and California in the fall and return via the same route in the spring. Portions of the park are also important staging areas for resident waterfowl. About 25-30 species are spring migrants and 22-23 species are fall migrants in BNP (Davidson 1985a, Holroyd and Van Tighem 1983). Most numerous are Red-necked Grebe, Canada Goose, Mallard, Green-winged Teal')>, Wigeon, Ring-necked Duck, Common Goldeneye, Barrow's Goldeneye, Common Merganser, and American Coot (Holroyd and Van Tighem 1983).

There is a relatively small amount of waterfowl staging and migration habitat in the Rocky Mountains and such areas in BNP (and JNP) are quite significant for this migration route. Most important are the backwaters, ponds and lakes of the Montane Ecoregion such as Vermilion Lakes, Cave and Basin Swamp, Johnson Lake and the Bow River backwater areas near the east gate. These areas have extensive beds of emergent and submerged vegetation which provide both food and cover. The fish populations also provide food.

Of moderate importance are Lower Subalpine lakes, reservoirs and *pool and riffle* reaches of rivers (Holroyd and Van Tighem 1983). This includes Wigmore Lake, Bow Lake, Peyto Lake, Waterfowl Lake, Lake Minnewanka and Two Jack Lake, and the lower and middle Bow River. The Bow River is of greatest importance during the spring when it is one of the first areas free of ice (Davidson 1985a). Harlequin Ducks use the river as a spring staging area, particularly the reaches below Lake Louise and Castle Junction (Holroyd and Van Tighem 1983).

Presently, the principal waterfowl staging areas in BNP are relatively unimpaired. Recreation in these areas is low during most of the migration periods and disturbance of migrating species is minor compared to resident species (Davidson 1985a) There is potential for toxic chemical spills into the Bow River and Vermilion Lakes from road and railroad traffic in the Bow Valley. However, there is a contingency plan for containment and cleanup of spills (McDonough 1983).

4.3.8 Waterfowl Nesting Areas

Thirty-six species of waterfowl occur in BNP (Holroyd and Van Tighem 1983). Of these, six are common or fairly common summer residents and eight are uncommon, rare, or very rare summer residents. Breeding is confirmed for 13 species and suspected for one other. Favorable nesting habitat is of very restricted extent, primarily occurring on a few lakes and backwaters in the Montane Ecoregion of the middle and lower Bow Valley and lower North Saskatchewan River. These include Vermilion Lakes, Cave and Basin Swamp, Fortymile Swamp, Warden Lake and oxbows and backwaters such as Muleshoe and Rainy Bay. Vermilion Lakes is the most extensive and important of these areas; at least seven species have bred there and two species, Red-necked and Pied-billed Grebes, occur nowhere else in BNP. A second type of nesting habitat is *pool and riffle* reaches of rivers. These include the Bow River between Castle Junction and Banff townsite and the Mistaya River below Waterfowl Lakes. These areas are important to Common Mergansers and Harlequin Ducks.

Many Montane waterbodies in BNP, such as Vermilion Lakes, Two Jack Lake, Johnson Lake and Lake Minnewanka, Muleshoe, and Cave and Basin Swamp, have been extensively manipulated in the past (Bow Valley Naturalists 1978, Holroyd and Van Tighem 1983). These areas currently receive much recreational use. The BNP Waterfowl Monitoring Plan (Ledwidge 1984a) will assess the status of waterfowl every fifth year. However, more frequent studies to assess the impact of recreation on waterfowl and other species may be needed.

4.3.9 Dipper Winter Areas

American Dippers (*Cinclus mexicanus*) are a common year-round resident in BNP although only part of the population remains in the park all winter. Those that do remain occur around any open water. They are usually solitary but may be densely concentrated along small, open stretches of rivers in winter and early spring. The density of Dippers between Banff and Canmore, during three Christmas bird counts (Holroyd and Gartshore 1978) was four per mile, the highest reported in Canada. Another

prime Dipper winter area is the Bow River from Lake Louise to Castle Junction (Holroyd and Van Tighem 1983).

Dippers feed on small fish and aquatic insects. Any pollution or disturbance of waters that would impair Dipper winter areas, especially on the Bow River, would affect the summer population of the entire park since these birds are highly concentrated on these limited wintering areas.

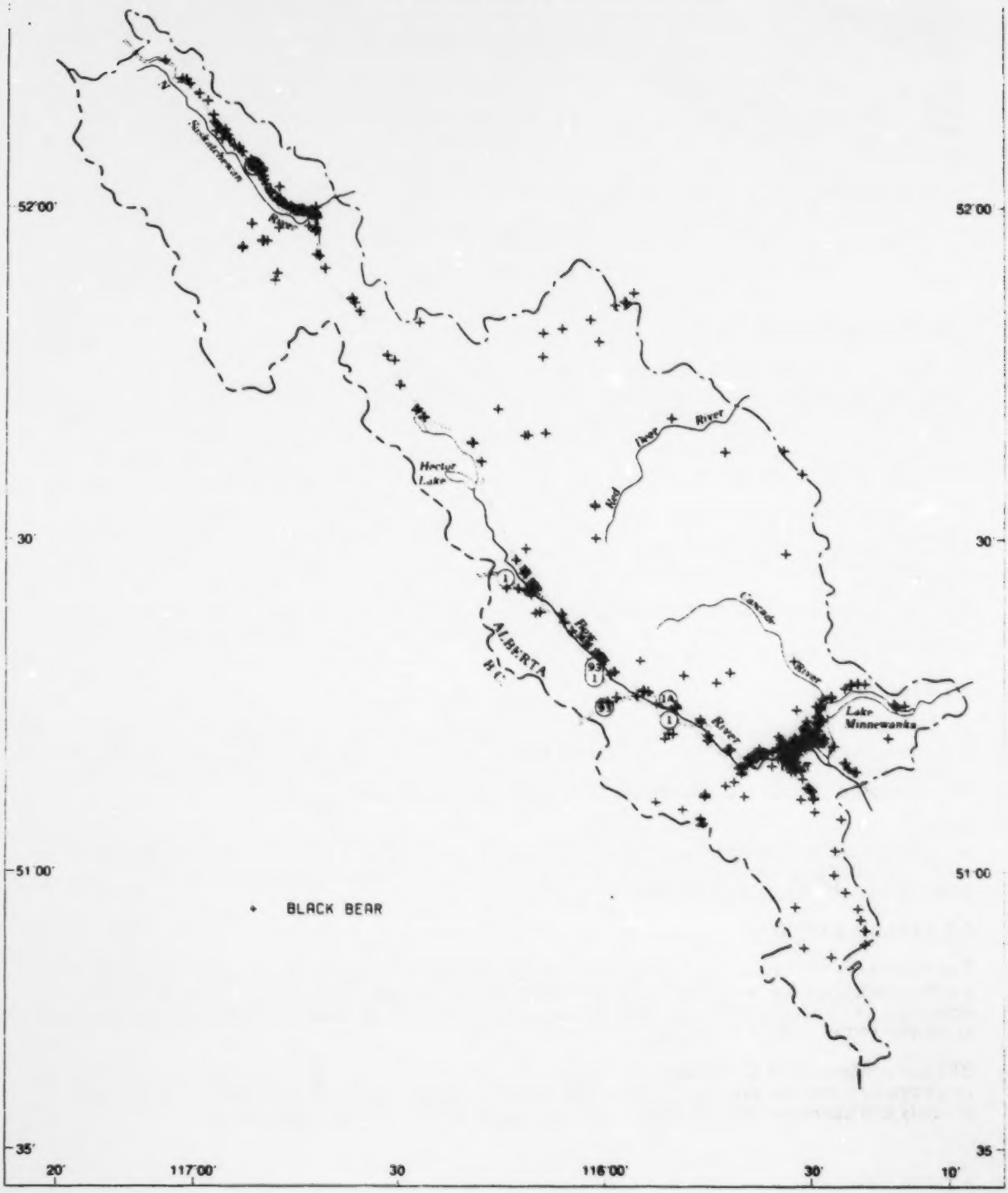
4.3.10 Black Bear Den Areas

Very little is known about the biology of black bears (*Ursus americanus*) in BNP. Most sightings are from the bottoms of the Bow Valley and North Saskatchewan River valley (Fig. 19) and it appears that black bears spend most of the year in the Montane and Lower Subalpine Ecoregions of these major river valleys (Holroyd and Van Tighem 1983). The population is currently estimated at about 120, although this is a crude estimate (Holroyd and Van Tighem 1983).

Black bears hibernate in dens from about October until April in BNP but very few dens are known. Most are in the Montane Ecoregion on slopes in coniferous forest. Several are known from the ridge between Rocky Mountain Resort and Tunnel Mountain Campground (Olson 1984) and another is near the recreation ground (Jacobson 1986). In 1968, a black bear sow denned and bore cubs in a culvert under the Mount Norquay road (Warden Wildlife Files 1945 - 1976).

Since black bear dens appear to be primarily in the Montane Ecoregion and especially around Banff townsite, there is a great potential for human impact on them. More information is needed on black bear den sites which should be gathered as part of a wider study of black bears in BNP. Radio collaring of trapped nuisance bears could help locate winter dens.

Fig. 19. Black bear observations in Banff National Park, 1975-1984.



5. ECOLOGICAL LAND CLASSIFICATION UNITS

The ecological land classification of BNP delineated landscape units (Ecosites) based on characteristic combinations of landform, soil and vegetation (Holland and Coen 1982). Wildlife characteristics were determined for each Ecosite following classification and mapping of Ecosites (Holroyd and Van Tighem 1983). The areal extent of Ecosites in BNP varies from about 100 ha to nearly 22,000 ha (CanSIS 1981). Ecosites which are of limited areal extent (<320 ha) or which are known from only one tract in BNP are considered special features in this study. While these units, by definition, contain rare *combinations* of landform, soil and vegetation, some also contain significant features already identified above. Thus, some Ecosites, such as HD4, have already been linked with significant features in various sections above.

Three of these significant Ecosites (GA1, HD4, PT3) occur in the Montane Ecoregion, four (BV3, IB3, ML2, VD2) in the Lower Subalpine, and four (AZ1, NG1, NT3, WH2) in the Upper Subalpine. Information in this section is from Holland and Coen (1982), unless otherwise cited.

5.1 Montane Ecosites

5.1.1 Garonne 1 (GA1)

The Garonne 1 (GA1) Ecosite is characterized by a calcareous, hummocky landform deposited by a landslide, with rapidly to well drained Brunisolic and Regosolic soils and lodgepole pine forest vegetation predominantly, with smaller amounts of aspen and Douglas fir forest and dry grasslands. GA1 occurs in BNP on only one tract (473 ha) which is in the Bow Valley between Johnston Creek and Hillsdale meadow. The landslide originated on the west side of Mount Ishbel and slid to and across the Bow River. It is composed primarily of calcareous siltstones and shales of the Sulphur Mountain Formation.

GA1 contains both the C16 (aspen forest) and H19 (dry grassland) vegetation types which are significant features (section 4.1.3). GA1 is also highly important to the significant mammals cougar and wolf (section 4.2.5), and is highly important to deer and elk. It also contains both a high diversity and density of birds (Holroyd and Van Tighem 1983).

The only other known tract of GA1 is in JNP near Garonne Creek. The tract in BNP has been somewhat disturbed by the Bow Valley Parkway which passes through it and is also adjacent to a tract of HD4 which is a significant Ecosite.

5.1.2 Hillsdale 4 (HD4)

Hillsdale 4 (HD4) occurs on calcareous, fluvial fan and apron landforms with Regosolic soils and predominantly a grassland vegetation (H6) with lesser amounts of lodgepole pine forest (C3). HD4 occupies about 167 ha in BNP in two tracts, both in the Bow Valley: one at Hillsdale meadow about 3 km southeast of Johnston Creek and the other in the vicinity of the Banff airfield.

HD4 contains the significant grassland vegetation types H6 and H13 (section 4.1.3), is highly important to ungulates and wolves, and is used by Bird Community 13, which is a significant feature (section 4.2.4) (Holroyd and Van Tighem 1983). Both tracts have been affected by highway and other facility development. HD4 also occurs in JNP in the Athabasca Valley.

5.1.3 Patricia 3 (PT3)

The Patricia 3 (PT3) Ecosite is typified by a landform pattern of morainal veneer over ridged bedrock and bare bedrock ridges with lithic phases of Brunisolic and Luvisolic soils and lodgepole pine forest vegetation. PT3 occupies 279 ha in BNP in three tracts, one on lower Sundance Creek and the other two at the east end of Lake Minnewanka.

PT3 also contains some C1 (Douglas fir) forest, which is a significant vegetation type (section 4.1.3), is very important for ungulates in winter and for wolf and cougar year round, and contains both a high diversity and number of birds (Holroyd and Van Tighem 1983). PT3 also occurs in JNP.

5.2 Lower Subalpine Ecosites

5.2.1 Bow Valley 3 (BV3)

The Bow Valley 3 (BV3) Ecosite is characterized by calcareous, glaciofluvial terrace landforms with Eutric Brunisols and spruce-fir closed forests (C13, C30). BV3 occurs on four tracts in BNP totalling 109 ha, one along the Glacier River above Glacier Lake and three along the Red Deer River between Douglas Lake and Horseshoe Lake.

BV3 is the least common of the BV Ecosites and is distinguished from them by having spruce-fir forests rather than lodgepole pine forests. This indicates that BV3 sites have been free of fire longer. Thus, the relative proportion of BV3 in the landscape is greatly influenced by fire frequency and any fire management practices, including supression and prescribed burning, should consider this. BV3 also occurs in JNP.

5.2.2 Ishbel 3 (IB3)

Ishbel 3 (IB3) includes hummocky landslide deposits derived from either calcareous or noncalcareous bedrock, with Brunisolic soils and spruce-fir closed forests (C21, C30). IB3 occurs in BNP on three tracts totalling 180 ha, one along Redearth Creek, one north of Lake Louise and another on Mount Sarbach. IB3 also occurs in JNP.

5.2.3 Moraine Lake 2 (ML2)

The Moraine Lake 2 Ecosite (ML2) is characterized by noncalcareous, morainal blanket landforms with deeply weathered Dystric Brunisols and lodgepole pine closed forests (C18, C20). ML2 occurs in BNP on two tracts totalling 317 ha, one on the south end of the Waputik Range and the other north of Cascade Mountain.

ML2 is distinguished from the more common ML1 Ecosite by having lodgepole pine vegetation rather than spruce-fir forests which reflects a greater fire frequency on ML2 tracts. Thus, altering fire frequencies by various fire management practices could affect the amount of ML2 in the landscape. ML2 also occurs in JNP where it is more extensive than in BNP.

5.2.4 Verdant 2 (VD2)

Verdant 2 (VD2) consists of noncalcareous fluvial fans with Dystric Brunisols and lodgepole pine forest vegetation (C9, C19). It occupies a total of 278 ha in BNP on eight tracts in the Bow Valley between Castle Junction and Lake Louise. These include fans formed by Louise Creek, Corral Creek, Moraine Creek, Taylor Creek and a small creek 1.5 km south of Taylor Creek where they flow into the Bow River. Other tracts are along the Pipestone River and Baker Creek.

VD2 is important to wolverines, cougars and wolves which are significant mammals (section 4.2.5) and contains a high bird species diversity (Holroyd and Van Tighem 1983). Only two of the eight tracts of VD2 in BNP have not been disturbed by highway or other facility development. VD2 also occurs in JNP.

5.3 Upper Subalpine Ecosites

5.3.1 Azure 1 (AZ1)

Azure 1 (AZ1) is characterized by ridged and hummocky landforms of noncalcareous, ice contact stratified drift which result in a dry-wet landscape pattern. The dry, upland portion contains Dystric Brunisols and spruce-fir closed or open forest (C15, O10), and the wet, depressional portions contain Gleysolic and Organic soils with wet shrub and herb meadow vegetation (S8, H9). AZ1 occupies a total of 254 ha in BNP and occurs on three tracts, one at Palliser Pass, one north of Haiduk Lake and the other on Molar Creek. The vegetation of the Palliser Pass tract has been significantly modified by fire. AZ1 is highly important to ungulates especially in summer (Holroyd and Van Tighem 1983). AZ1 also occurs in JNP.

5.3.2 Nigel 1 (NG1)

The Nigel 1 (NG1) Ecosite is characterized by calcareous, glaciofluvial terrace landforms with Eutric Brunisols and spruce-fir closed and open forests. NG1 occurs only in BNP where it occupies 299 ha on three tracts, one east of Red Deer Lakes, another northeast of Red Deer Lakes and the third is at the confluence of Hilda and Nigel Creeks. The tract at Nigel Creek has been disturbed by road and facility development.

5.3.3 Num-Ti-Jah 3 (NT3)

Num-Ti-Jah 3 (NT3) contains fluviolacustrine floodplains with Gleysolic and Organic soils, and wet meadow and fen vegetation (H9, H10, H11), forming a landscape of fens with occasional ponds and small lakes. Only two tracts of NT3, totalling 103 ha, occur in BNP, one at Bow Pass and the other in Castleguard Meadows. NT3 also occurs in JNP where it is more common than in BNP.

5.3.4 Whitehorn 2 (WH2)

Whitehorn 2 (WH2) is characterized by noncalcareous, colluvial blanket and veneer landforms with Dystric Brunisols and spruce-fir closed and open forests (C15, O10). It occupies a total of 252 ha on nine small tracts, one south of Marvel Lake, another east of Twin Lakes, five in the Lipalian Mountain - Whitehorn Mountain area, one in the lower Pipestone River valley and one in upper Peters Creek. WH2 also occurs in JNP where it is more common than in BNP.

6. CULTURAL RESOURCES

Evidence of man's early presence in BNP has been found at several hundred sites. The significance of the sites is often not clear and many other highly significant sites probably still await discovery. Therefore, this evaluation of cultural resources will deal with general spatial and temporal patterns to recommend special protection priorities. Cultural resources are divided into *prehistoric*, which predate European contact with local native peoples about 1775, and *historic*, those after 1775.

6.1 Prehistoric Cultural Resources

The earliest human use of BNP likely dates to ca. 11,000 to 11,500 BP, based on artifacts from the Lake Minnewanka area (Reeves 1972). However, the earliest, firmly-dated evidence is from a Vermilion Lakes site where the lowest cultural levels date to about 10,500 BP (Fedje 1986). Archaeological researchers in BNP commonly use the Northwestern Plains/Mountain prehistoric temporal scheme (Frison 1978, Reeves 1969). This divides the paleocultural record into Early, Middle and Late periods based on major developments in hunting technology. The *Early Prehistoric*or Paleo-Indian Period (ca. 11,500 - 7800 BP) is characterized by large projectile points, possibly used as spear heads. During the *Middle Prehistoric* or Plains Archaic Period (ca. 7800 - 1500 BP), dart points appear to have been used with an atlatl. The *Late Prehistoric* Period is recognized by the presence of smaller projectile points for arrows.

Table 6 lists prehistoric sites located to date in BNP. Site significance is rated by the Archaeological Research Unit, Western Region, Parks Canada as:

undetermined (U) - site located but not well tested (treat as High)

low (L) - site of minimal importance

moderate (M) - site of moderate importance

high (H) - site highly significant.

The degree of disturbance due to human or natural activity is: *undisturbed* (U), *partially disturbed* (PD), *largely disturbed* (LD), or *destroyed* (D). Fig. 20 shows the location of the prehistoric sites.

Christensen (1971) states that "the settlement pattern of the aboriginal inhabitants of Banff Park is closely tied to the seasonal and spatial distribution of resources within each valley." This spatial variability of use allows some generalizations to be made about the distribution and significance of prehistoric sites.

6.1.1 Low Elevation Sites

Although climate and ecological conditions have changed through time, low elevation areas along the Bow River, Red Deer River and North Saskatchewan River probably always offered the most favorable environments for human occupation in BNP (Christensen 1971, Damp *et al.* 1980). Thus, the greatest density of long term occupation sites such as base camps and pit houses should be found in these areas. Examples of significant low elevation areas include the following.

Lake Minnewanka Area: The damming and raising of the lake inundated much prehistoric evidence, however two important sites remain (EhPu-1, EhPt-2). EuPu-1, near where the Cascade River enters Lake Minnewanka, provided artifacts for collectors such as Harlin Smith and William Peyto before 1920 (Reeves 1972). Subsequent investigations (Christensen 1971, McIntyre and Reeves 1975, Reeves 1976) have found that it was an important Early and Mid-Prehistoric base camp. The site is being damaged by wave erosion from the lake.

Johnson Lake: Although of only moderate significance, a high density of sites occurs around the Johnson Lake shoreline (EhPu-6,7,8,9 and 10). Porter (1979) collected numerous artifacts at EhPu-6 from the Late Prehistoric period. Continued heavy day use along the shore is eroding the surface of many sites here (Steer 1979).

Fig. 20. Prehistoric sites of Banff National Park.

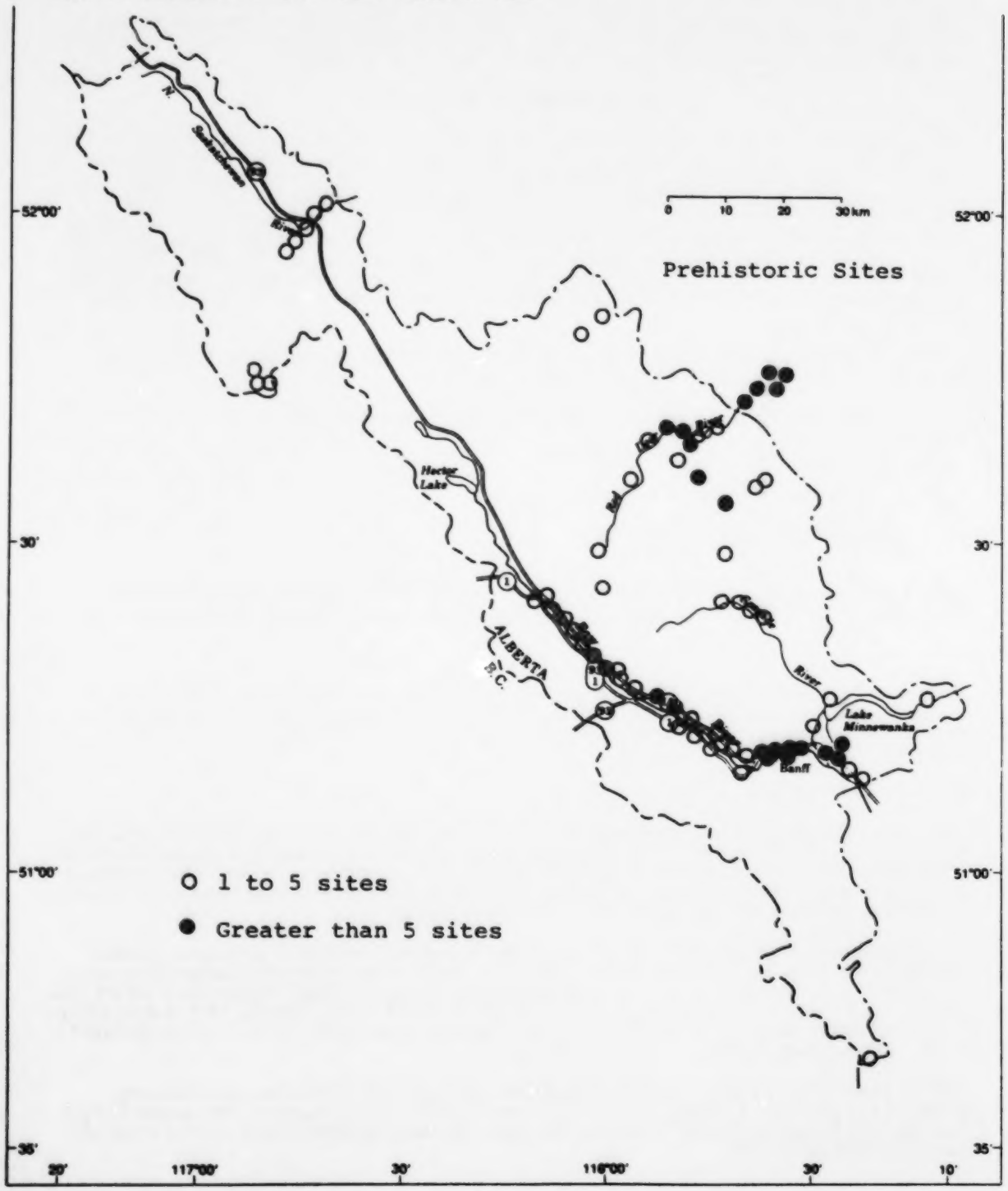


Table 6. Prehistoric sites of Banff National Park and the Ya Ha Tinda Ranch. Significance: Undetermined, High, Moderate, Low. Disturbance: U = undisturbed, PD = partially disturbed, LD = largely disturbed, D = destroyed.

Site	Sig.	Dist.	Feature	Location	Source
EfPu-1	U	PD	campsite	Palliser Pass	Reeves 1972
EgPu-2	M	LD	campsite	TCH picnic area	Steer & Porter 1981
EgPu-11	U	LD	campsite	Carrot Creek	Steer & Porter 1981
EgPu-12	U	U	tools	Carrot Creek	Steer & Porter 1981
EgPu-13	U	LD	campsite	Carrot Creek	Steer & Porter 1981
EgPv-1	H	U	quarry	Bow Falls	Fedje 1982
EgPv-2	M	LD	hot spring	Middle Springs	Steer 1982
EgPw-1	L	LD	bison bone	Healy Creek	Sumpter 1984
EhPt-1	H	PD	campsite	Devil's Gap	Christensen 1971
EhPu-1	H	LD	base camp	Stewart Canyon	Christensen 1971
EhPu-2	U	LD	campsite	Carrot Creek	Steer & Porter 1981
EhPu-3	L	PD	campsite	Chinaman Creek	Steer & Porter 1981
EhPu-4	M	D	misc.	TCH	Steer & Porter 1981
EhPu-5	M	LD	campsite	Duthil	Steer & Porter 1981
EhPu-6	H	PD	campsite	Johnson Lake	Porter 1979
EhPu-7	H	PD	campsite	Johnson Lake	Steer 1979
EhPu-8	H	U	campsite	Johnson Lake	Steer 1979
EhPu-9	M	PD	workshop	Johnson Lake	Steer 1979
EhPu-10	H	LD	campsite	Johnson Lake	Steer 1979
EhPu-13	L	U	tool	Anthracite	Steer & Porter 1981
EhPu-15	L-M	U	misc.	Anthracite	Steer & Porter 1981
EhPu-21	H	U	misc.	Johnson Lake	Sumpter 1984
EhPv-2	H	PD	campsite	Hoodoos	Christensen 1971
EhPv-3	U	LD	campsite	Vermilion Lakes	Fedje 1982
EhPv-4	U	U	cave	Mt. Norquay	Christensen 1971
EhPv-5	H	PD	campsite	Edith Creek	Christensen 1971
EhPv-6	U	PD	campsite	Fivemile Creek	Christensen 1971
EhPv-7	H	PD	basecamp	Vermilion Lakes	Christensen 1971
EhPv-8	H	LD	campsite	Fivemile Creek	Christensen 1971
EhPv-9	H	PD	campsite	Fivemile Creek	Christensen 1971
EhPv-10	L	D	campsite	airport	Porter 1983
EhPv-11	H	PD	campsite	Bankhead	Christensen 1971
EhPv-12	H	LD	pithouses	golf course	Christensen 1971
EhPv-13	U	PD	campsite	Indian Grounds	Christensen 1971
EhPv-14	M	PD	campsite	Banff E. overpass	Steer & Porter 1981
EhPv-15	H	PD	quarry	Banff W. overpass	Christensen 1971
EhPv-16	U	PD	campsite	Cadet Camp	Christensen 1971
EhPv-17	H	PD	campsite	Hoodoos	Christensen 1971
EhPv-20	U	PD	campsite	Duthil	Steer & Porter 1981
EhPv-21	U	U	misc.	Duthil	Steer & Porter 1981
EhPv-24	H	PD	campsite	Recreation Centre	Fedje 1982
EhPv-27	M-H	PD	campsite	airport	Wilson 1984
EhPv-31	U	PD	campsite	Banff E. overpass	Porter 1984
EhPv-32	H	PD	campsite	Indian Grounds	Porter 1984
EhPv-38	H	PD	campsite	Banff W. overpass	Porter 1984
EhPv-39	H	LD	campsite	Vermilion Lakes	Porter 1984
EhPv-40	U	U	campsite	Vermilion Lakes	Porter 1984
EhPv-41	M	U	campsite	Vermilion Lakes	Porter 1984
EhPv-42	U	U	campsite	Vermilion Lakes	Porter 1984
EhPv-43	U	U	campsite	Vermilion Lakes	Porter 1984
EhPv-45	H	PD	campsite	Vermilion Lakes	Porter 1984
EhPv-46	U	U	misc.	Edith Creek	Porter 1984
EhPv-47	H	PD	base camp	Vermilion Lakes	Porter 1984
EhPv-48	U	PD	campsite	Vermilion Lakes	Porter 1984
EhPv-50	U	U	campsite	Edith Creek	Porter 1984
EhPv-51	M	D	campsite	Vermilion Lakes	Porter 1984
EhPv-54	L	U	tool	Fivemile Creek	Porter 1984

Site	Sig.	Dist.	Feature	Location	Source
EhPv-58	H	PD	campsite	Vermilion Lakes	Porter 1984
EhPv-67	U	LD	bison bones	Cave & Basin	Porter 1984
EhPv-71	U	PD	kill site	Vermilion Lakes	Porter 1984
EhPv-72	M	LD	campsite	Vermilion Lakes	Fedje 1984
EhPv-73	L	D	bison bones	Banff	Porter 1984
EhPv-74	U	U	tools	Fivemile Creek	Fedje 1984
EhPv-78	H	LD	campsite	Banff W. overpass	Sumpter 1984
EhPv-79	U	LD	misc.	Vermilion Lakes	Wilson 1984
EhPv-80	M	PD	campsite	Vermilion Lakes	Wilson 1984
EhPv-81	M	PD	campsite	Vermilion Lakes	Wilson 1984
EhPv-82	U	LD	campsite	Vermilion Lakes	Wilson 1984
EhPv-83	U	PD	quarry	Mt. Norquay	Wilson 1984
EhPv-88	M	U	campsite	Fortymile Creek	Wilson 1984
EhPv-89	U	U	quarry	Fortymile Creek	Wilson 1984
EhPv-91	L	LD	misc.	Bison Paddock	Wilson 1984
EhPv-94	U	PD	campsite	Bison Paddock	Wilson 1984
EhPv-95	U	LD	campsite	Indian Grounds	Wilson 1984
EhPv-96	U	LD	misc.	Indian Grounds	Wilson 1984
EhPv-97	H	U	campsite	Indian Grounds	Wilson 1984
EhPv-98	U	PD	campsite	CPR station	Wilson 1984
EhPv-99	U	LD	campsite	CPR station	Wilson 1984
EhPv-100	H	PD	campsite	Tunnel Mtn.	Wilson 1984
EhPv-101	U	LD	campsite	Tunnel Mtn.	Wilson 1984
EhPw-1	H	LD	base camp	Mt. Cory	Christensen 1971
EhPw-2	H	LD	base camp	backswamp	Damp *et al.* 1980
EhPw-3	H	LD	base camp	backswamp	Christensen 1971
EhPw-4	H	LD	base camp	Muleshoe	Damp *et al.* 1980
EhPw-5	U	PD	campsite	Muleshoe	Christensen 1971
EhPw-6	U	U	campsite	Sawback Range	Christensen 1971
EhPw-7	U	PD	campsite	Ranger Canyon	Christensen 1971
EhPw-8	U	PD	campsite	Massive	Christensen 1971
EhPw-9	U	LD	campsite	Massive	Christensen 1971
EhPw-10	H	PD	campsite	Hillsdale	Christensen 1971
EhPw-11	H	PD	campsite	Muleshoe	Steer and Porter 1982
EhPw-12	U	PD	misc.	Mt. Cory	Steer 1979
EhPw-13	H	PD	quarry	Mt. Bourgeau	Fedje 1984
EhPw-14	M-H	PD	fossils	Redearth Creek	Fedje 1984
EhPw-17	L	D	bones	Wolverine Creek	Porter 1984
EhPw-18	M	PD	campsite	Wolverine Creek	Sumpter 1984
EhPw-21	M	LD	campsite	Mt. Brett	Porter 1984
EhPw-22	U	PD	campsite	Redearth Creek	Sumpter 1984
EhPx-1	L	U	misc.	Baker Creek	Fedje 1983
EhPx-5	U	PD	campsite	Silver City	Porter 1981
EhPx-6	U	LD	campsite	Castle Junction	Porter 1981
EhPx-7	U	LD	campsite	Castle Junction	Steer & Fedje 1982
EhPx-8	U	LD	campsite	Castle Junction	Steer & Fedje 1982
EhPx-10	U	D	campsite	Castle Junction	Steer & Fedje 1982
EhPx-11	L	U	misc.	Castle Junction	Steer & Fedje 1982
EhPx-12	U	LD	campsite	Castle Junction	Steer & Fedje 1982
EhPx-13	U	PD	campsite	Castle Junction	Steer & Fedje 1982
EhPx-15	U	D	kill site	Castle Junction	Steer & Fedje 1982
EhPx-18	U	PD	misc.	Eldon	Steer & Fedje 1982
EhPx-19	L	U	misc.	Eldon	Steer & Fedje 1982
EhPx-20	L	U	misc.	Eldon	Steer & Fedje 1982
EhPx-21	L	PD	misc.	Eldon	Steer & Fedje 1982
EhPx-22	U	PD	misc.	Castle Junction	Steer & Fedje 1982
EhPx-23	L	PD	misc.	Castle Junction	Steer & Fedje 1982
EhPx-26	M	U	campsite	Castle Junction	Steer & Fedje 1982
EhPx-31	U	PD	campsite	Castle Junction	Sumpter 1984
EiPw-1	U	PD	campsite	Wigmore Summit	Christensen 1971
EiPw-3	U	PD	campsite	Flints Park	Christensen 1971

Site	Sig.	Dist.	Feature	Location	Source
EiPw-4	U	PD	campsite	Flints Park	Christensen 1971
EiPw-5	U	PD	workshop	Flints Park	Christensen 1971
EiPw-6	U	PD	workshop	Flints Park	Christensen 1971
EjPw-1	H	LD	base camp	Scotch Camp	Christensen 1971
EjPw-7	U	PD	campsite	Scotch Camp	Christensen 1971
EjPw-8	U	PD	campsite	Scotch Camp	Christensen 1971
EjPw-9	U	PD	campsite	Scotch Camp	Christensen 1971
EjPw-10	U	PD	campsite	Scotch Camp	Christensen 1971
EjPw-11	U	LD	campsite	Windy cabin	Christensen 1971
EjPw-12	U	LD	campsite	Windy cabin	Christensen 1971
EjPw-13	U	PD	campsite	Windy cabin	Christensen 1971
EjPw-14	U	PD	campsite	Windy cabin	Christensen 1971
EjPw-16	U	PD	workshop	Snow Creek Pass	Christensen 1971
EjPw-17	U	PD	campsite	Snow Creek Pass	Christensen 1971
EjPw-18	U	PD	workshop	Snow Creek Pass	Christensen 1971
EjPw-19	U	PD	workshop	Snow Creek Pass	Christensen 1971
EjPw-20	U	PD	quarry	Snow Creek Pass	Christensen 1971
EjPw-21	U	U	campsite	Snow Creek Pass	Christensen 1971
EjPw-23	U	PD	campsite	Snow Creek Pass	Christensen 1971
EjPw-24	U	U	workshop	Snow Creek Pass	Christensen 1971
EjPw-25	U	PD	workshop	Snow Creek Pass	Christensen 1971
EjPw-26	U	PD	campsite	Snow Creek Pass	Christensen 1971
EjPw-27	U	PD	workshop	Panther River	Christensen 1971
EjPw-28	U	PD	campsite	Wigmore Creek	Christensen 1971
EjPw-29	U	PD	campsite	Scotch Camp	Christensen 1971
EjPw-30	U	PD	campsite	Scotch Camp	Christensen 1971
EjPv-1	U	PD	misc.	Panther R. spring	Christensen 1971
EjPx-1	U	U	overlook	Mt. Prow	Christensen 1971
EjPx-3	U	U	campsite	Scotch Camp	Christensen 1971
EjPx-4	U	PD	campsite	Scotch Camp	Christensen 1971
EjPx-5	U	PD	campsite	Scotch Camp	Christensen 1971
EjPx-7	U	U	cairns	Scotch Camp	Christensen 1971
EjPx-8	U	PD	campsite	Scotch Camp	Christensen 1971
EjPx-9	U	PD	campsite	Horseshoe L.	Christensen 1971
EjPx-10	U	U	campsite	McConnell Ck.	Christensen 1971
EkPv-1	L	U	fifty	Ya Ha Tinda	Anderson 1970
to	to	to		Ranch	J. Elliot 1970
EkPv-50	H	D	sites	area	S. Elliot 1970
EkPw-1	U	LD	campsite	Scotch Camp	Christensen 1971
EkPw-2	U	LD	campsite	Scotch Camp	Christensen 1971
EkPw-4	U	LD	campsite	Scotch Camp	Christensen 1971
EkPw-5	U	PD	workshop	Tyrrell Creek	Christensen 1971
EkPw-6	U	LD	workshop	Tyrrell Creek	Christensen 1971
EkPw-7	U	PD	workshop	Tyrrell Creek	Christensen 1971
EkPw-8	U	PD	workshop	Tyrrell Creek	Christensen 1971
EkPx-4	H	PD	campsite	Divide Creek	Christensen 1971
EkPx-5	H	LD	campsite	Divide Creek	Christensen 1971
EkPx-6	U	PD	campsite	Divide Creek	Christensen 1971
EkPx-7	U	LD	campsite	Divide Creek	Christensen 1971
EkPx-8	U	PD	campsite	Divide Creek	Christensen 1971
EkPx-9	U	PD	campsite	Divide Creek	Christensen 1971
EkPx-10	U	PD	campsite	McConnell Ck.	Christensen 1971
EkPx-11	U	PD	workshop	McConnell Ck.	Christensen 1971
EkPx12	U	PD	campsite	McConnell Ck.	Christensen 1971
ElPx-1	U	PD	campsite	Indianhead Ck.	Christensen 1971
EhQa-1	U	PD	campsite	Eldon	Christensen 1971
EhQa-2	L	LD	misc.	Baker Creek	Steer & Fedje 1982
EhQa-3	U	LD	flakes	Baker Creek	Steer & Fedje 1982
EhQa-8	U	PD	flakes	Protection Mtn.	Steer & Fedje 1982
EhQa-11	L	U	misc.	Baker Creek	Steer & Fedje 1982
EiQa-1	L	LD	flakes	McNair Pond	Christensen 1971

Site	Sig.	Dist.	Feature	Location	Source
EiQa-2	H	PD	campsite	Halfway Hut	Christensen 1971
EiQa-3	L	LD	misc.	Corral Creek	Steer & Fedje 1982
EiQa-4	L	LD	misc.	Corral Creek	Steer & Fedje 1982
EiQa-8	M	U	misc.	Baker Creek	Steer & Fedje 1982
EiQa-14	M	LD	flakes	Corral Creek	Steer & Fedje 1982
EiQb-1	H	LD	campsite	Pipestone R.	Christensen 1971
EiQb-6	U	LD	lookout	Lake Louise	Anderson 1975
EjQa-1	U	PD	campsite	Red Deer Lakes	Christensen 1971
EjQa-2	U	PD	campsite	Red Deer Lakes	Christensen 1971
EjQa-3	U	PD	campsite	Red Deer Lakes	Christensen 1971
EkQa-3	U	PD	campsite	Malloch Creek	Christensen 1971
EkQe-1	U	PD	campsite	Conway Creek	Christensen 1971
EkQe-2	U	LD	workshop	Howse Pass	Christensen 1971
EkQe-4	U	LD	workshop	Conway Creek	Christensen 1971
ElQe-1	U	PD	campsite	Sask. Crossing	Christensen 1971
ElQe-2	U	U	flakes	Sask. Crossing	Christensen 1971
ElQe-3	U	PD	flakes	Sask. Crossing	Christensen 1971
ElQe-4	U	PD	campsite	Sask. Crossing	Christensen 1971
ElQe-5	U	U	flakes	Sask. Crossing	Christensen 1971
ElQe-6	U	U	flakes	Sask. Crossing	Christensen 1971
ElQe-7	U	U	campsite	Sask. Crossing	Christensen 1971
ElQe-8	U	PD	base camp	Sask. Crossing	Christensen 1971
ElQe-9	U	PD	campsite	Sask. Crossing	Christensen 1971
ElQe-10	U	U	campsite	Owen Creek	Christensen 1971
ElQe-11	U	U	campsite	Owen Creek	Christensen 1971

Whiskey Creek: Site EhPv-24 is on an eolian beach ridge along Whiskey Creek near Banff townsite. Preliminary investigation of this base camp site showed intermittent occupation for the past 6500 years (Fedje 1982b). The sand dune landform in which it lies may result in better preservation than most BNP sites and, although it is partly disturbed by a small borrow pit, it has a high archaeological potential. Several other sites near Whiskey Creek also have high or moderate value (Wilson 1984).

Fivemile Creek and Vermilion Lakes Area: This area provided prehistoric peoples with excellent base camp locations. Several sites, including EhPv-6,7,8,9,15 and 43 have been evaluated (Christensen 1971, Fedje 1982b). EhPv-8 has provided significant information for interpreting both local and regional prehistory (Fedje 1984,1986) with carbon dating indicating an age of earliest human use of about 10,500 BP. Construction of the Trans-Canada Highway has damaged or destroyed many sites in the area, although some salvage work was done.

Banff Springs golf course: Originally 14 pit houses were found at the present location of the golf course (Reeves 1972). Currently, evidence of three structures (EhPv-12) still remains under the third fairway. Testing of these sites could provide valuable information (Christensen 1971).

Sawback Area: Several sites have been surveyed along the base of the Sawback Range from Fivemile Creek to Hillsdale (Christensen 1971, Damp *et al.* 1980, Fedje 1986). The lower slopes of Mount Cory and Mount Ishbel apparently provided good base camp sites similar to those in the Vermilion Lakes area. Use of EhPw-2 dates to before 9000 BP (Damp *et al.* 1980). Construction and maintenance of the Bow Valley Parkway and the railroad, and heavy visitor use have damaged these sites.

Scotch Camp Area: A high concentration of prehistoric sites occurs along the lower Red Deer River valley (Christensen 1971). These include the only intact pit house sites in the Rocky Mountains (EkPx-4,5) and numerous campsites (*e.g.* EjPx-4,8; EkPx-2,4,11 and 12). This low elevation area probably provided a wide diversity of plant and animal resources for prehistoric peoples (Christensen 1971). For example, the remains of buffalo wallows occur in the Scotch Camp meadows (Banfield 1958). Construction of the Cascade Fire Road, Red Deer River trail and Scotch Camp Warden Cabin have all damaged several sites.

Ya Ha Tinda Ranch: Although outside BNP, the Ya Ha Tinda area is under Parks Canada's jurisdiction and contains a significant quantity of prehistoric campsites (Reeves 1972). Many of these have been disturbed by road construction and natural erosion.

Saskatchewan Crossing Area: Eleven prehistoric sites are known from the Montane Ecoregion in the Saskatchewan Crossing area (Christensen 1971). ElQi-8 appears to be a base camp, dating to at least the Mid-Prehistoric period.

6.1.2 Mid-Elevation Sites

Although environmentally less favorable to prehistoric human use than low elevation valley bottom sites, mid-elevation areas probably provided resources for spring, summer and fall periods (Christensen 1971, Damp *et al.* 1980). Campsites were apparently used only seasonally and thus do not provide the richness of artifacts of low elevation sites. However, several significant areas are known and include the following.

Red Deer River Headwaters: Sites EjQa-1,2 and 3 are campsites which may illustrate prehistoric human use patterns in the Subalpine Ecoregion (Christensen 1971, Reeves 1972).

Cascade River: Of six sites currently known in the Cascade Valley, EiPw-4 is a probable campsite that may contain significant evidence (Reeves 1972).

Panther River: Several sites are known along the Panther River, particularly near Windy Cabin (Christensen 1971) and EjPw-11,12,15 and 22 require preservation for further testing (Reeves 1972).

Howse River: The mid-elevations of the Howse River valley contain several sites, mostly near Howse Pass (Christensen 1971). EkQe-1 and 3 could provide information on use of the area (Reeves 1972).

6.1.3 Upper Elevation Sites

Small hunting groups of prehistoric people probably used upper elevation areas only in the summer (Christensen 1971). These people camped in only a limited number of small sites, while the majority of use occurred in lower elevation areas. Significant upper elevation sites include the following.

Snow Creek Pass: Eleven sites are currently known from this area (Christensen 1971). EjPw-18,21,23 and 26 are thought to be particularly valuable for understanding the primary processing of lithic materials into tools. Past construction activity along the Cascade Road damaged several sites (Reeves 1972).

Corral Creek: Site EiQa-2 at Ptarmigan Halfway Hut is disturbed by current camping and should be preserved for further excavation (Christensen 1971).

Palliser Pass: EfPu-1 should be preserved for further testing (Reeves 1972).

6.2 Historic Cultural Resources

Human use of BNP since 1775 has left abundant evidence ranging from wooden native tombs to motels in the present townsite. Assessing the value of cultural features from the Historic period is thus a subjective task. However, as a general rule, any structure more than 40 years old may have historic value (Yeo 1985). Surveys of historic resources have been done for the Lake Louise area (Cockerton 1978), the Trans-Canada Highway Km 0 to 13 (Steer and Porter 1981), Bow Valley Parkway (Steer and Fedje 1982), the Banff townsite (Epler 1985) and outlying buildingsin BNP (Friesen 1985). Additional information of historic site locations is drawn from the staff of Parks Canada and the Whyte Museum of the Canadian Rockies. General patterns of historic land use which often refer to locations of special historic significance are described by Byrne (1964), Fraser (1969), Van Kirk (1969) and Scace (1968).

Table 7 lists historic sites from the above sources. The levels of significance and disturbance categories are the same as for prehistoric sites above. In addition those in Table 7, over 200 other structures have been inventoried in the Banff townsite area (Epler 1985, Freisen 1985). Fig. 21 shows the location of these sites. In evaluating *significance*, the relevance of sites to historic people and land-use trends in BNP are primarily considered. For this purpose, a modified version of Byrne's (1964) historical periods is used.

Fig. 21 Historic sites in Banff National Park.

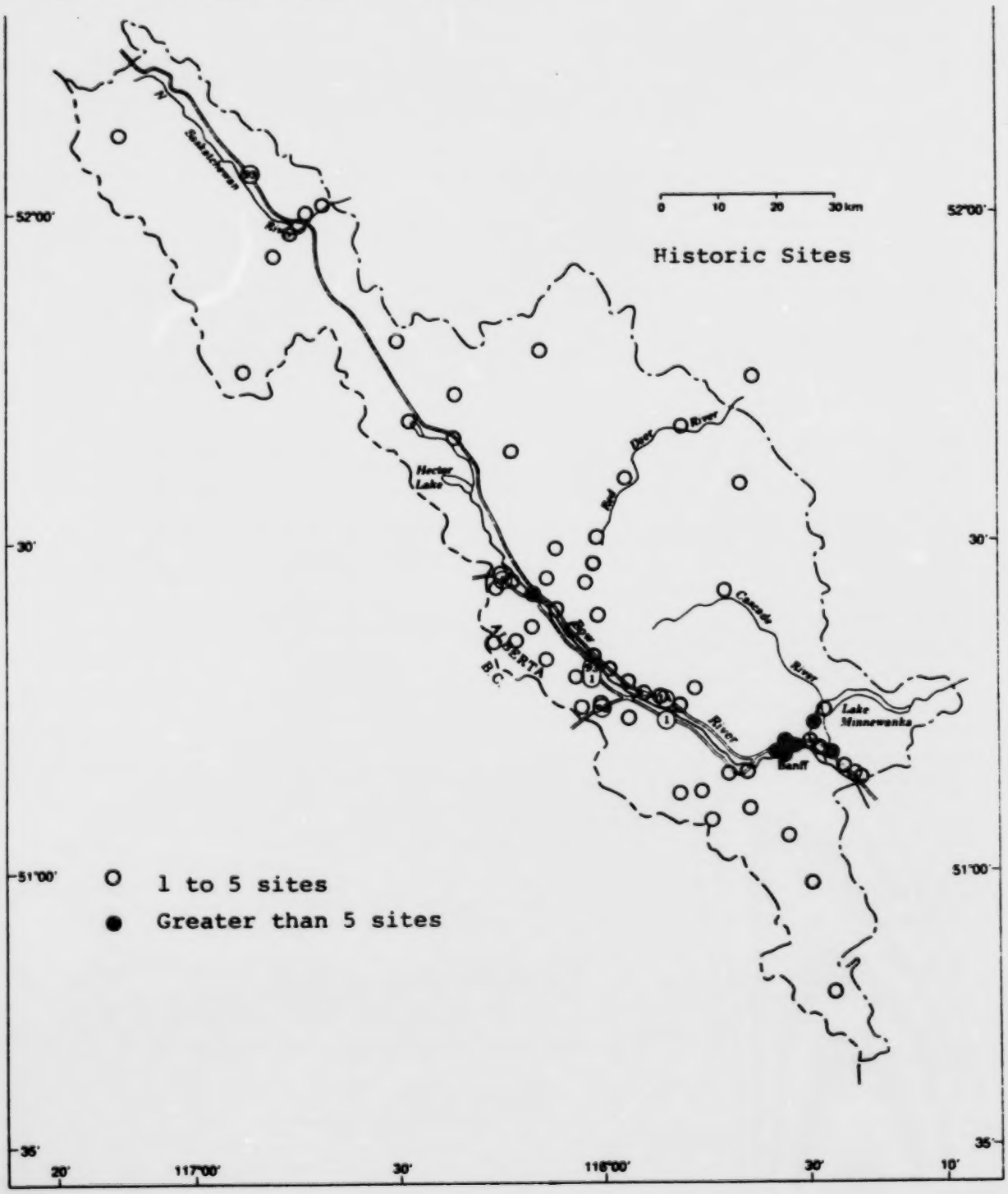


Table 7. Historic sites of Banff National Park. Significance: Undetermined, High, Moderate, Low. Disturbance: U = undisturbed, PD = partially disturbed, LD = largely disturbed, D = destroyed.

Site	Sig.	Dist.	Feature	Location	Source
EgPu-1	U	U	cairns	Carrot Creek	Steer & Porter 1981
EgPw-20	U	PD	dump	Wolverine Creek	Sumpter 1984
EgPx-1	M	PD	Peyto's cabin	Simpson Pass	Warden Service
EhPu-11	M	D	town	Anthracite	Steer & Porter 1981
EhPu-12	L	PD	log ramps	Duthil	Steer & Porter 1981
EhPu-14	M	LD	fish hatchery	Duthil	Steer & Porter 1981
EhPu-16	L	U	dump	Duthil	Steer & Porter 1981
EhPu-17	L	D	well	Chinaman Creek	Steer & Porter 1981
EhPu-18	U	LD	mine	Anthracite	Steer & Porter 1981
EhPu-19	U	D	market garden	Anthracite	Steer & Porter 1981
EhPu-20	M	LD	cabin	Johnson Lake	Steer & Porter 1981
EhPv-18	H	PD	NWMP post	Banff	Gardner 1975
EhPv-19	M	U	power plant	Anthracite	Steer & Porter 1981
EhPv-22	U	PD	pumphouse	Banff E. overpass	Steer & Porter 1981
EhPv-23	M	PD	mine	Anthracite	Steer & Porter 1981
EhPv-25	U	LD	internment camp	Sulphur Mtn.	Porter 1984
EhPv-26	H	LD	Cave & Basin	Sulphur Mtn.	Porter 1984
EhPv-30	L	PD	dump	Banff E. overpass	Porter 1984
EhPv-33	L	U	dump	Whiskey Ck.	Porter 1984
EhPv-34	L	LD	fence	Cascade Mtn.	Porter 1984
EhPv-35	L	PD	cabin	Fortymile Ck.	Porter 1984
EhPv-36	L	PD	cellar	Fortymile Ck.	Porter 1984
EhPv-37	L	LD	cabin	Fortymile Ck.	Porter 1984
EhPv-44	U	D	foundation	Vermilion Lakes	Porter 1984
EhPv-55	L	U	wall	Anthracite	Steer & Porter 1981
EhPv-56	U	PD	cellar	Anthracite	Steer & Porter 1981
EhPv-57	U	PD	berms	Anthracite	Steer & Porter 1981
EhPv-59	M	LD	barn	Bankhead	Porter 1984
EhPv-60	L	PD	cellar	Bankhead	Porter 1984
EhPv-61	U	LD	Chinatown	Bankhead	Porter 1984
EhPv-62	U	LD	dump	Bankhead	Porter 1984
EhPv-63	L	PD	cellar	Bankhead	Porter 1984
EhPv-64	L	D	berm	Cave & Basin	Porter 1984
EhPv-65	M	LD	pool	Cave Ave.	Porter 1984
EhPv-66	L	D	cellar	Cave & Basin	Porter 1984
EhPv-68	U	LD	berms	Banff W. overpass	Porter 1984
EhPv-69	L	PD	pit	Fivemile bridge	Head 1984
EhPv-70	L	PD	coal piles	Banff	Head 1984
EhPv-77	M	PD	pit	Banff	Fedje 1984
EhPv-84	M	PD	tent frame	Fortymile Ck.	Wilson 1984
EhPv-85	M	PD	tent frame	recreation grounds	Wilson 1984
EhPv-86	H	U	Luxton cabin	Banff	Wilson 1984
EhPv-87	L	LD	fence	Banff E. overpass	Wilson 1984
EhPv-90	U	U	pit	Bison Paddock	Wilson 1984
EhPv-92	U	PD	pit	Cave & Basin	Wilson 1984
EhPv-93	U	U	foundation	Bison Paddock	Wilson 1984
EhPv-102	L	PD	pit	Banff	Sumpter 1984
EhPw-16	L	LD	bridge footing	Wolverine Ck.	Porter 1984
EhPw-19	L	U	dump	Sunshine overpass	Sumpter 1984
EhPx-2	H	LD	town	Silver City	Porter 1981
EhPx-3	M	LD	cabin	Moose Meadows	Steer 1979
EhPx-4	L	PD	cabin	Castle Junc.	Porter 1981
EhPx-9	L	D	dump	Castle Junc.	Steer & Fedje 1982
EhPx-14	U	PD	internment camp	Castle Junc.	Steer & Fedje 1982
EhPx-16	U	PD	logging camp	Eldon	Steer & Fedje 1982
EhPx-17	U	PD	dump	Eldon	Steer & Fedje 1982
EhPx-24	U	U	campsite	Castle Junc.	Steer & Fedje 1982

Site	Sig.	Dist.	Feature	Location	Source
EhPx-25	L	U	log structure	Castle Junc.	Steer & Fedje 1982
EhPx-28	L	LD	dump	Castle Junc.	Porter 1984
EhPx-29	M	U	survey marker	Castle Junc.	Porter 1984
EhPx-30	M	U	survey marker	Castle Junc.	Porter 1984
EhPx-32	L	U	dump	Copper Lake	Sumpter 1984
EjPx-6	U	LD	campsite	Scotch Camp	Christensen 1971
EhQa-4	L	U	structure	Protection Mtn.	Steer & Fedje 1982
EhQa-5	L	LD	logging camp	Protection Mtn.	Steer & Fedje 1982
EhQa-6	M	U	spring	Protection Mtn.	Steer & Fedje 1982
EhQa-7	U	U	CPR cabin	Eldon	Steer & Fedje 1982
EhQa-9	U	U	foundation	Protection Mtn.	Steer & Fedje 1982
EhQa-10	L	U	log structure	Baker Creek	Steer & Fedje 1982
EhQa-12	L	U	fence	Baker Creek	Steer & Fedje 1982
EhQa-13	L	U	structure	Protection Mtn.	Steer & Fedje 1982
EhQa-14	L	PD	structure	Protection Mtn.	Steer & Fedje 1982
EhQa-15	L	PD	structure	Protection Mtn.	Steer & Fedje 1982
EiQa-5	L	U	dump	Corral Creek	Steer & Fedje 1982
EiQa-6	L	PD	pit	Corral Creek	Steer & Fedje 1982
EiQa-7	M	U	cabin	Corral Creek	Steer & Fedje 1982
EiQa-9	L	U	cabin	Protection Mtn.	Steer & Fedje 1982
EiQa-10	M	U	mining camp	Protection Mtn.	Steer & Fedje 1982
EiQa-11	U	U	mining camp	Protection Mtn.	Steer & Fedje 1982
EiQa-12	M	U	mine shaft	Protection Mtn.	Steer & Fedje 1982
EiQa-13	U	U	structure	Baker Creek	Steer & Fedje 1982
EiQb-2	U	PD	structure	Holt City	Anderson 1975
EiQb-3	L	LD	dump	Lake Louise	Anderson 1975
EiQb-4	H	PD	CPR houses	Lake Louise	Anderson 1975
EiQb-5	H	PD	grave	Lake Louise	Anderson 1975
EiQb-7	L	LD	cabin	Lake Louise	Anderson 1975
EiQb-8	M	PD	logging camp	Bath Creek	Anderson 1975
EiQb-9	U	PD	quarry	Bath Creek	Anderson 1975
EiQb-10	L	U	depression	Lake Louise	Anderson 1975
EiQb-11	L	PD	cabin	Lake Louise	Anderson 1975
EiQb-12	L	PD	dump	Lake Louise	Anderson 1975
EiQb-13	H	D	hotel	Lake Louise	Porter 1981
EiQb-14	M	U	houses	Lake Louise	Porter 1981
EkQc-1	H	PD	Num-Ti-Jah Lodge	Bow Lake	Warden Service
ElQd-1	H	PD	log tombs	Owen Creek	Christensen 1971
ElQe-12	U	LD	burial pit	Mt. Wilson	Christensen 1971
-	H	U	residence	313 Buffalo	Epler 1985
-	H	U	residence	501 Buffalo	Epler 1985
-	H	U	residence	505 Buffalo	Epler 1985
-	H	U	residence	119 Cave	Epler 1985
-	H	U	residence	103 Caribou	Epler 1985
-	H	U	residence	607 Caribou	Epler 1985
-	H	U	residence	118 Grizzly	Epler 1985
-	H	U	hotel	Banff Springs	Epler 1985
-	H	U	Admin. Bldg.	Banff	Epler 1985
-	H	U	Admin. gardens	Banff	Warden Service
-	H	U	King Edward Hotel	Banff	Epler 1985
-	H	U	Bank of Commerce	Banff	Epler 1985
-	H	U	Museum	Banff	Epler 1985
-	H	U	CPR station	Banff	Epler 1985
-	H	U	Bow R. bridge	Banff	Freisen 1985
-	H	PD	dance hall	Banff	Epler 1985
-	H	U	White store	Banff	Epler 1985
-	H	U	auditorium	Banff	Epler 1985
-	H	U	Anglican church	Banff	Epler 1985
-	H	PD	East Park Gate	Trans-Canada Hwy.	Freisen 1985
-	H	PD	Upr. Hot Spgs.	Banff	Freisen 1985
-	H	U	Post Hotel	Lake Louise	Freisen 1985

Site	Sig.	Dist.	Feature	Location	Source
-	H	U	CPR station	Lake Louise	Freisen 1985
-	H	PD	Great Divide Gate	Lake Louise	Freisen 1985
-	H	U	teahouse	Lake Louise	Freisen 1985
-	H	U	Chateau L. Louise	Lake Louise	Freisen 1985
-	U	U	Deer Lodge Hotel	Lake Louise	Freisen 1985
-	U	U	Moraine L. Lodge	Lake Louise	Freisen 1985
-	U	U	Paradise Bungalows	Lake Louise	Freisen 1985
-	U	U	bungalows	Johnston Canyon	Freisen 1985
-	U	PD	Swiss Guide Chalet	Lake Louise	Freisen 1985
-	U	U	warden cabin	Johnston Ck.	Freisen 1985
-	U	U	warden cabin	Lake Louise	Freisen 1985
-	U	U	cabin	Boom Creek	Freisen 1985
-	U	U	cabin	Mud Lake	Freisen 1985
-	U	U	cabin	Mosquito Ck.	Freisen 1985
-	U	U	warden cabin	Scotch Camp	Freisen 1985
-	U	LD	warden cabin	Bankhead	Freisen 1985
-	U	U	warden cabin	Egypt Lake	Freisen 1985
-	U	LD	cabin	Healy Creek	Freisen 1985
-	U	U	warden cabin	Cuthead	Freisen 1985
-	U	U	warden cabin	Bryant Creek	Freisen 1985
-	U	U	warden cabin	Clearwater Lks.	Freisen 1985
-	U	U	mine camp	Panorama Ridge	Freisen 1985
-	U	U	warden cabin	Little Pipestone	Freisen 1985
-	U	LD	trapper cabin	Glacier L.	Freisen 1985
-	U	LD	trapper cabin	Mt. Weed	Freisen 1985
-	U	LD	warden cabin	Alexandra R.	Freisen 1985
-	U	LD	Thorington cabin	Freshfield Glacier	Freisen 1985
-	U	U	Sandhills cabin	Red Deer R.	Freisen 1985
-	U	U	warden cabin	Ya Ha Tinda	Freisen 1985
-	U	U	warden cabin	Divide Creek	Freisen 1985
-	U	LD	cabin	Panther River	Warden Service
-	L	PD	Simpson cabin	Sask. Xg.	Warden Service
-	L-M	PD	Glacier cabin	Owen Creek	Warden Service
-	L-M	PD	Dolomite cabin	Isabella L.	Warden Service
-	L-M	PD	Siffleur cabin	Siffleur R.	Warden Service
-	L-M	U	Pipestone Pass cabin	Pipestone Pass	Warden Service
-	L-M	U	Cyclone cabin	Red Deer Lks.	Warden Service
-	L	U	Palliser cabin	Spray River	Warden Service
-	L	LD	logging camps	Spray River	Warden Service
-	L	LD	logging camps	Brewster Creek	Warden Service
-	L	U	Storm Mtn. Lodge	Vermilion Pass	Warden Service
-	L	PD	Ptarmigan Halfway	Corral Creek	Warden Service
-	L	U	Skoki Lodge	Mt. Skoki	Warden Service
-	L	U	Sunshine Lodge	Sunshine Village	Warden Service
-	L	U	Strom's Halfway	Brewster Ck.	Warden Service
-	L	PD	mine works	Copper Mtn.	Warden Service
-	H	U	Abbott Pass Hut	Bow Range	Warden Service

6.2.1 Fur Trading Period Sites (ca. 1775 - 1850)

The BNP area was only lightly used by European man during the early 1800's. David Thompson of the Northwest Company crossed Howse Pass (a National Historic Site) on June 25, 1807 (Hopwood 1971). Sir George Simpson, Chief Factor of the Hudson Bay Company, traversed Simpson Pass in 1841 (Fraser 1969). However, the hostile Peigan tribe blocked routine use of passes across the Rockies in the park by fur traders. The Stoney Indians appear to have used the BNP area extensively for hunting and trapping during this period. The Saskatchewan Crossing Indian tombs (ElQd-1) may date from this period and several other campsites show evidence of use during this time (Christensen 1971). Father De Smet and James Sinclair crossed Whiteman Pass during the 1840's. On June 27, 1847, Reverend Robert Rundle held a service for Stoney Indians, possibly near the present Banff townsite (Fraser 1969).

6.2.2 Prospecting and Early Railroad Period Sites (1850 - 1886)

Despite the large amount of prospecting and goldrush activity in western Canada, the BNP region was infrequently visited by prospectors, due to poorly-known travel routes, before the coming of the railway (Byrne 1964). James Hector of the Palliser Expedition explored Vermilion and Kicking Horse passes 1885 (Spry 1963). Several pre-1890 cabin remains have been found in the Bow Valley, including EhPx-25 and EiQa-7 (Steer and Fedje 1982), which may be evidence of early European trappers and prospectors. According to pioneer Andrew Sibbald, four Americans prospected in the Banff area in 1875 and may have built a cabin seen by Government Inspector Pierce in 1884 (Byrne 1964).

In 1882 and 1883, the Canadian Pacific Railroad surveyed potential routes through Howse Pass and Kicking Horse Pass, and built the railroad over the latter in 1883 and 1884 (Bone 1947, Wilson 1972). Bath Creek was named when Major A.B. Rogers, the Chief Surveyor, was bucked off his horse while fording the stream in 1881. Numerous logging and construction camps date to early railroad activity in the Bow Valley. Most are in an advanced stage of decomposition and have low historic value (Steer and Fedje 1982). However, some such as the original Lake Louise Station buildings (EiQb-4) built around 1884 are typical of the period (Anderson 1975). The original station house itself was moved to Heritage Park in Calgary in 1975.

A mining boom occurred in the Bow Valley concurrently with railroad construction. Silver City (EhPx-2) grew to 150 inhabitants before being almost totally abandoned by 1886 (Byrne 1964). The site has since been heavily disturbed by railroad and highway activities. Old mine workings from this boom occur on the slopes of the Bow Valley between Johnston Creek and Baker Creek (*e.g.* the Copper Mountain workings).

The early development of the hot springs on Sulphur Mountain began a chain of events that lead to the creation of of Canada's first national park. The Cave and Basin (EhPv-26) is a National Historic Site (Steer and Porter 1982).

6.2.3 Early Park Period (1887 - 1910)

Early national park policy encouraged the continued expansion of mining and logging in BNP (Byrne 1964). The Anthracite coal mines, for example, continued until 1904. Sites related to the mine (*e.g.* EhPv-19 and EhPu 11,18) have been mostly eliminated by subsequent railway and highway construction (Steer and Porter 1981). Coal mines at Bankhead operated from 1905 to 1923 (Byrne 1964). Parks Canada has developed an interpretive program for the area which has been largely disturbed by post-1923 park management (*e.g.* EhPv-59,60,61,62; Porter 1984). The mine workings on Protection Mountain (EiQa-10,11,12) also date to this period (Steer and Fedje 1982). The Eau Claire Lumber Company had several logging camps in the Spray River valley until a large fire swept the area in 1908 (White 1985a). Other logging camps of this era were along Brewster Creek and near Lake Louise (*e.g.* EiQb-8; Anderson 1975).

Trapping and prospecting also continued in the backcountry of BNP during this period (Hart 1979). Significant sites include Bill Peyto's cabin on Healy Creek and Jimmy Simpson's cabin at Saskatchewan Crossing.

From 1887 to 1910, Banff townsite expanded to much the same extent it has today (Byrne 1964) and structures of this period still remain (Epler 1985). These include the train station, White Block, Anglican Church, Luxton cabin, Superintendent's residence and the Natural History Museum. Many other structures of this age continue to be lost through redevelopment. In Lake Louise, the current railroad station was constructed in 1908 (Cockerton 1978).

6.2.4 Post-1910 Sites

In 1909, the Warden Service was established to protect the wildlife and vegetation of BNP (Byrne 1964). By 1919, wardens had built a system of 66 cabins connected by 400 km of telephone line in the mountain parks (Department of the Interior 1921). Early patrol cabins still existing include: Glacier cabin (Owen Creek), Dolomite cabin, Siffleur cabin, Pipestone Pass cabin, Cyclone cabin and Palliser cabin. Many are either abandoned or scheduled for replacement. The second Windy Cabin, probably built in the 1930's, was moved to the Whyte Museum as a display cabin.

Annual visitor use of BNP increased from less than 10,000 in 1900 to approximately 180,000 in 1930 with a attendant rapid increase in facilities (Department of the Interior 1902, 1932). The original Banff Springs Hotel, commissioned by Cornelius Van Horne in 1884, burned down in 1926 and was reconstructed to its present form by 1928 (Robinson 1973). In 1924, the Chateau Lake Louise also burned and was rebuilt by 1926 (Cockerton 1978). In 1922, Jimmy Simpson built the original Num-Ti-Jah Lodge (EkQc-1), a log structure still standing on the shores of Bow Lake next to the newer lodge which was built in 1938 (Hart 1979). Storm Mountain Lodge also dates to the 1920's. Early ski lodges still in good condition and of historic value include: Ptarmigan Halfway cabin (1933), Skoki (1933), Sunshine (1929) and Strom's Halfway. Epler (1985) summarizes the numerous other buildings in the Banff townsite that may have historic value.

6.3 Management Considerations

Many of the cultural resource sites in BNP are rare and fragile. The past 100 years of tourist, industrial and transportation facility development in the park has degraded or destroyed many cultural sites (Reeves 1981). Examples of permanent impairment include the pit houses on the Banff Springs golf course and prehistoric campsites along the shore of Lake Minnewanka and near Muleshoe along the Bow Valley Parkway.

The cultural sites of BNP are a nonrenewable resource which as a repository of heritage information should be carefully assessed and, wherever possible, preserved (Steer and Fedje 1982). To accomplish this, the following management considerations are needed.

Location and Documentation

Continued work is needed to locate and document prehistoric and historic sites. The last general inventory of the park was done by Christensen (1971), and subsequent work has been scattered, project specific and often of a salvage nature (Reeves 1981). More detailed location and inventory of sites is needed, particularly in the Clearwater River, Siffleur River and North Saskatchewan River valleys.

Preservation of Prehistoric Sites

In contrast to most other lands, Parks Canada's policy of restricting development presents an opportunity for long-term preservation of a large number of prehistoric sites. These sites can be left unimpaired for future archaeological investigations that may use better technological and dating techniques than those currently available. Thus, current management policy limits the excavation and disturbance of sites to salvage operations necessitated by park development of site-specific areas (Fedje 1985b). However, Reeves (1981) observes for the Bow Valley that "prospects are poor for in-place preservation, not only because of the multiplicity of impacts, both private and public, but also because of the lack of a comprehensive management program."

Therefore, if long term, in-place preservation is desired, the maximal protection status of a *special zone* must be given to all locations with significant prehistoric resource potential. In BNP, this includes:

1. the areas immediately around all sites currently identified as of high, moderate or unknown significance (Table 6).

2. undeveloped Montane Ecoregion areas in the Bow Valley and North Saskatchewan River valley. These regions were favored by prehistoric peoples and have a high potential for undiscovered base camps and other highly significant sites. Montane Ecosites with high prehistoric potential include FR1, HD1 and VL4.

3. limited areas in the valley bottoms of the Siffleur River, Spray River, Cascade River, Panther River, Clearwater River and Red Deer River where the potential for prehistoric sites is high. This includes the AL1, BV1, PP3, PP6, and PP7 Ecosites.

4. the Ya Ha Tinda Ranch which, although outside the park, is under federal jurisdiction and has a high archaeological potential that needs careful management.

The areas described above could be released from special zone status once detailed studies have shown a lack of significant prehistoric sites.

Preservation of Historic Sites

The quantity (>400) and varied importance of historic sites in BNP makes total preservation both impractical and unnecessary. However, significant historic sites should be preserved to interpret the various historic periods. These might include:

- Fur Trading Period: Howse Pass, Whiteman Pass, Indian tombs.

- Prospecting and Early Railroad Period: Silver City.

- Early Park Period: Cave and Basin, Bankhead, various townsite buildings, Peyto cabin, Simpson cabin.

- Post-1910 Period: Glacier cabin, Windy Cabin, Num-ti-jah Lodge, Ptarmigan Halfway Hut, Skoki Lodge, various buildings in Banff townsite and Lake Louise.

Salvage Studies

Despite preservation efforts, destruction of some cultural sites by future development will be unavoidable. The current program of salvage studies for sites about to be disturbed by development must be continued.

7. NATURAL AREAS OF SIGNIFICANCE

7.1 Introduction

The preceding sections identify and describe significant *features* in BNP, such as rare species, physical features of scientific interest or vegetation communities of limited areal extent. These individual features occur in many locations throughout the park. However, to properly protect and manage these significant features, it is necessary to delineate special areas where these features, or combinations of them, occur. These special areas, termed *natural areas of significance*, are not currently formal *zones* in a park management plan but are intended to flag particular areas as containing significant resources worthy of special management consideration. All of the natural areas of significance described below contain more than one significant feature, although not all significant features are included in the natural areas of significance. Delineation of these areas also allows a cross-disciplinary consideration of features by area rather than the disciplinary organization used in the preceding sections. For example, the description of the Johnston Creek natural area of significance draws together information on surficial geology, hydrologic features, rare plants, birds and mammals, significant Bird Communities, plant communities and Ecosites, significant ungulate seasonal ranges, and prehistoric cultural sites. Additionally, the Index, which contains both *feature* and *area* entries, will be useful in determining the extent of a feature or the features in an area.

Twenty-seven natural areas of significance (Fig. 22) are described below in terms of their location, significant features and management concerns, where appropriate.

7.2 Area Descriptions

7.2.1 Bow Lake

The Bow Lake natural area of significance extends from the south end of Bow Lake, north along the Icefields Parkway to the north end of Peyto Lake and then south to include the Peyto Glacier (Fig. 22). It contains an igneous dike near the southern end of Bow Lake; Bow Lake, Peyto Lake and the Peyto Glacier are scientifically significant; there are four species of rare plants (*Botrychium lanceolatum*, *Draba albertina*, *Epilobium luteum*, *Ranunculus verecundus*) a tract of a significant Ecosite (NT3) at Bow Pass, and Num-Ti-Jah Lodge, at the northern end of the lake, is a historic site.

7.2.2 Carrot Creek

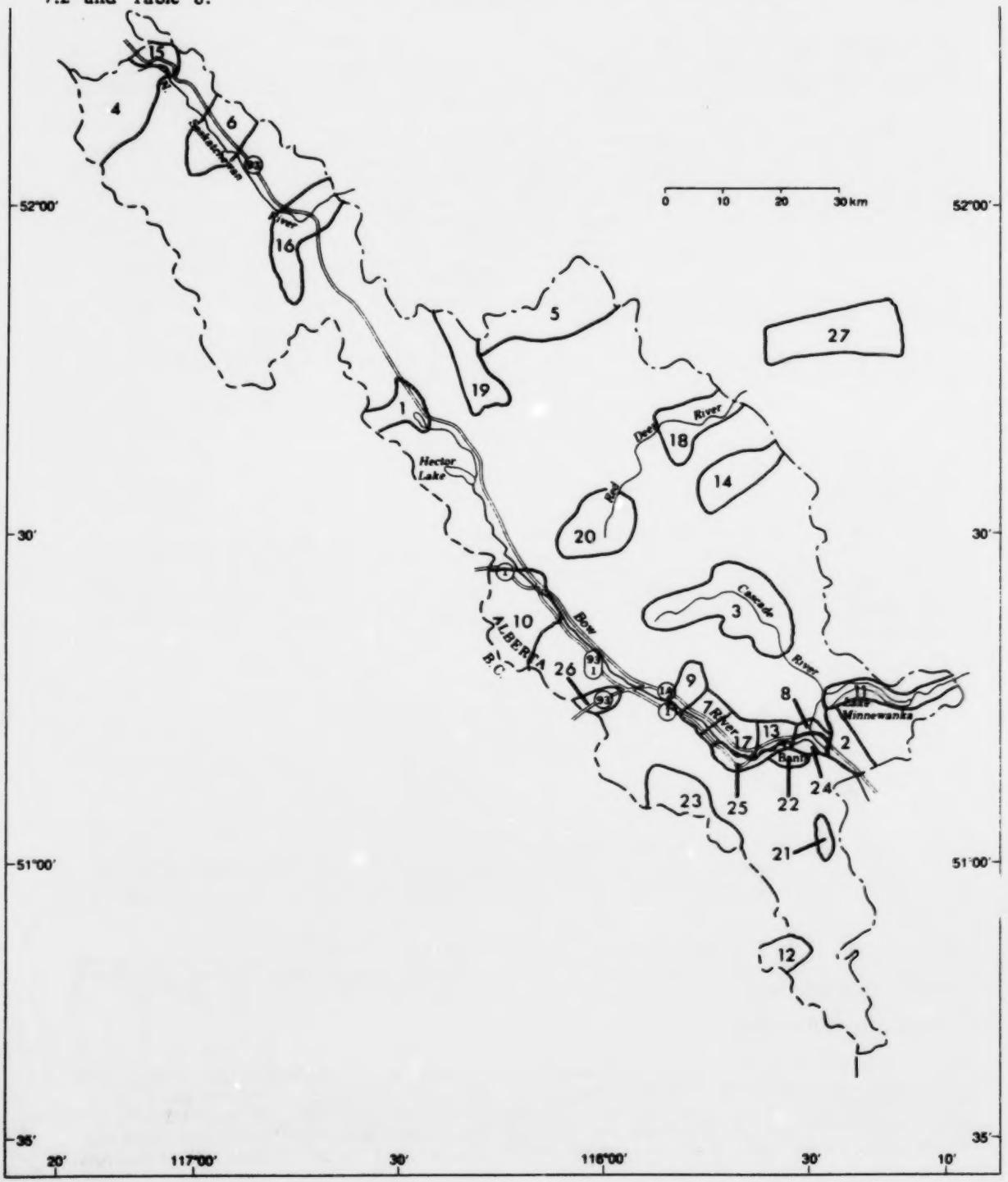
The Carrot Creek natural area of significance runs northwest along the Bow River and Cascade River from the eastern boundary of the park to the Two Jack Canal and along the lower slopes of the Fairholme Range to the north (Fig. 22). Its significant features include: Johnson Lake, hoodoos along the Cascade River, rare plants (*Carex illota*, *Veronica catenata*), the oldest Douglas fir in Alberta, significant Montane grassland and forest communities (C1, C16, C9, O5, H6, H7), rare animals (spotted frog, long-toed salamander, Osprey, Red-necked Grebe, Wood Duck, Northern Phalarope, muskrat), significant Bird Communities (1,9,13), waterfowl nesting and staging areas, deer and elk winter range, elk calving areas and both prehistoric and historic sites. This area also contains the only undisturbed tracts of the HD1 Ecosite (fluvial fan with C16 aspen forest in the Montane Ecoregion) in the park. The largest of these is 0.5 km north of Johnson Lake. Two smaller tracts occur northwest of Carrot Creek.

The area is part of the Montane Ecoregion in the lower Bow Valley which is perhaps the most vital and varied part of BNP. It is also among the most heavily impacted by development and particular care is needed to minimize further impact.

7.2.3 Cascade - Flints Park

The Cascade - Flints Park natural area of significance is centered on Flints Park in the upper Cascade River valley and extends west to Block Mountain, southeast to Stoney Creek, and north along the Palliser Range to Wigmore Lake (Fig. 22). It contains native cutthroat trout, the highest density of grizzly bears in the park, Golden Eagle nest sites, ungulate mineral licks, wolf habitat, sheep fall and winter range, elk fall range, goat winter range and contains tracts of the SF1 Ecosite with permafrost.

Fig. 22 Natural areas of significance in Banff National Park. Area numbers are in section 7.2 and Table 8.



7.2.4 Castleguard Meadows

The Castleguard Meadows natural area of significance extends roughly from Mount Athabasca east to the end of the Saskatchewan Glacier, southwest to Terrace Mountain and Watchman Peak, and west to the British Columbia boundary (Fig. 22). It contains portions of several glaciers, the Castleguard Cave system, numerous springs, two species of rare invertebrate animals (*Salmasellus steganothrix* and *Stygobromus canadensis*), a tract of NT3, a significant Ecosite, and areas of neoglacial landscape.

7.2.5 Clearwater River

The Clearwater River natural area of significance includes the watersheds of Martin Creek, Malloch Creek and Indianhead Creek, all north of the Clearwater River to the park boundary (Fig. 22). The area includes hoodoos along the Clearwater River, tracts of the SF1 Ecosite with permafrost, rare plants (*Saxifraga flagellaris*), significant birds (Western Meadowlark), ungulate mineral licks, elk fall range, sheep summer and winter range, wolf habitat and prehistoric cultural sites.

7.2.6 Graveyard Flats

The Graveyard Flats natural area of significance is centered on the confluence of the North Saskatchewan River and Alexandra River and extends from Mount Amery and Amery Creek, north to Cirrus Mountain and south to Mount Coleman, Sunset Pass and Norman Creek (Fig. 22). It contains neoglacial and fluvial landscapes of scientific and hydrologic interest, significant animals (spotted frog, Sharp-tailed Sparrow, Tree Sparrow, Western Flycatcher), rare plants (*Aster xmaccallae, Erysimum pallasii, Habenaria unalascensis, Haplopappus uniflorus, Rhododendron lapponicum, Salix lanata* ssp. *calcicola*), significant vegetation types (C12, O11) and goat winter range.

7.2.7 Hillsdale

The Hillsdale natural area of significance extends from Mount Ishbel and Ishbel Pass, southwest to the Bow River, along the Bow River west to Mount Cory and northwest along the upper part of the Sawback Range (Fig. 22). The area includes a rare fossil site at Massive, rare plants (X*Agroelymus mossii, Crepis atrabarba, Ranunculus grayi*), significant Montane vegetation types (O5, H6, H7, H19), rare birds (Osprey, Long-eared Owl), significant Bird Communities (1,9,13), winter range for elk, moose, sheep and deer, significant Montane Ecosites (GA1, HD4), and prehistoric cultural sites.

7.2.8 Indian Grounds

The Indian Grounds natural area of significance extends along Banff Avenue from the turn-off to the industrial compound, past the Indian Grounds to the Minnewanka interchange, along the Trans-Canada Highway to the Banff airfield, and along the base of Cascade Mountain to Fortymile Creek and the junction of the Trans-Canada Highway with the industrial compound access road (Fig. 22). It contains significant Montane vegetation types (C16, H6) and Ecosites (HD4), rare birds (Upland Sandpiper, Calliope Hummingbird, Franklin's Gull), significant Bird Communities (1,13), elk and deer winter range, is an important wildlife migration corridor and contains both prehistoric and historic cultural resource sites.

7.2.9 Johnston Canyon

The Johnston Canyon natural area of significance includes the Johnston Creek valley from the Ink Pots to the Bow River and across to the Trans-Canada Highway (Fig. 22). It includes significant geological features (the canyon and falls), the Castle Mountain viewpoint fossil site, the Ink Pots springs, rare plants (*Hieracium cynoglossoides, Lithophragma glabrum, Lithophragma parviflorum*), rare birds (Black Swift, Western Flycatcher), rare mammals (water shrew, Richardson's water vole, wolverine), significant Bird Communities (1,9), significant Montane vegetation types (C1, H6) and Ecosites (GA1), elk, deer and moose winter range and prehistoric sites.

7.2.10 Lake Louise

The Lake Louise natural area of significance extends roughly from Kicking Horse Pass, east to Whitehorn Mountain, south to Moraine Creek and southwest to Mount Babel, including Lake Louise, Paradise Valley, Moraine Lake, and the lower parts of the Pipestone River and Corral Creek (Fig. 22).

The area contains a large number of special features including: Lake Louise and Moraine Lake themselves, Giant Steps waterfall, twenty-six species of rare plants (*XAgroelymus bowdenii*, *XAgroelymus mossii*, *XAgroelymus turneri*, *Agrostis mertensii*, *Arenaria longipedunculata*, *Arnica parryi*, *Aster xmaccallae*, *Botrychium lanceolatum*, *Bromus altissimus*, *Carex deflexa*, *Draba fladnizensis*, *Draba ventosa*, *Erysimum pallasii*, *Habenaria unalascensis*, *Hieracium cynoglossoides*, *Juncus biglumis*, *Juncus parryi*, *Mitella breweri*, *Pedicularis racemosa*, *Poa stenantha*, *Polygonum austiniae*, *Ranunculus verecundus*, *Ribes laxiflorum*, *Saxifraga nelsoniana*, *Saxifraga nivalis*, *Sorbus sitchensis*), significant vegetation types (C9, C23), significant birds (Hawk Owl, Snowy Owl, Swamp Sparrow), rare mammals (water shrew, wolverine), goat and moose winter range, dipper winter habitat and waterfowl staging areas along the Bow River, significant Ecosites (IB3, VD2, WH2) and both prehistoric and historic cultural sites.

7.2.11 Lake Minnewanka

The Lake Minnewanka natural area of significance includes all of the lake from the dam to Devil's Gap and the lower slopes on either side (Fig. 22). The lake itself is a significant feature and others include: a spring, hoodoos, loess deposition areas, rare plants (*Hieracium cynoglossoides*), significant animals (Red-necked Grebe, Franklin's Gull, muskrat), significant Bird Communities (1,9), ungulate mineral licks, sheep, deer and elk winter range, waterfowl staging areas, a significant Ecosite (PT3), and prehistoric cultural sites.

7.2.12 Marvel Lake

The Marvel Lake natural area of significance extends from Marvel Pass to Bryant Creek and west to Wonder Pass, including Marvel, Gloria and Owl Lakes (Fig. 22). It contains rare plants (*Erigeron purpuratus*, *Mitella breweri*, *Pedicularis racemosa*, *Rorripa tenerrima*), pure populations of Westslope Cutthroat Trout, Golden Eagle nests and a significant Ecosite (WH2).

7.2.13 Mount Norquay

The Mount Norquay natural area of significance extends north of the Trans-Canada Highway from Fortymile Creek to Fivemile Creek. It contains rare plants (*Castilleja hispida*, *Crepis atrabarba*, *Draba reptans*, *Hieracium cynoglossoides*, *Lithophragma parviflorum*, *Pellaea glabella*), significant vegetation types (C1, O5, H6, H7, H13) and Bird Communities (1,13), significant habitat for cougars and black bears, deer, elk and sheep winter range, a wildlife migration corridor, and prehistoric cultural resource sites.

7.2.14 Panther River

The Panther River natural area of significance includes the Panther River valley from the falls to the park boundary and the slopes on both sides of the river (Fig. 22). The area contains sulphur springs, permafrost in tracts of the SF1 Ecosite, rare plants (*Haplopappus uniflorus*, *Polygonum austiniae*, *Rumex pauciflorus*, significant birds (Peregrine Falcon, Golden Eagle, Red-eyed Vireo) and mammals (Richardson's water vole, wolves, grizzly bears), ungulate mineral licks, elk fall and winter range, sheep summer and winter range, cougar habitat, a significant vegetation type (C33) and prehistoric sites.

7.2.15 Parker Ridge

The Parker Ridge natural area of significance extends from Mount Athabasca to the end of the Saskatchewan Glacier and along the lower part of Nigel Creek and to Sunwapta Pass (Fig. 22). It contains Panther Falls, rare plants (*Arenaria longipedunculata*, *Braya humilis* var. *porsildii*, *Erigeron purpuratus*, *Juncus biglumis*), rare birds (Peregrine Falcon), goat winter range and a significant Ecosite (NG1).

7.2.16 Saskatchewan Crossing

The Saskatchewan Crossing natural area of significance extends from David Creek on the Howse River, north and east to Glacier Lake and along the North Saskatchewan River valley east to the park boundary (Fig. 22). The area is an outlier of the Montane Ecoregion in northern BNP and contains neoglacial landscapes and braided fluvial channels of scientific interest, canyons (Mistaya River), Owen Creek), springs, loess deposition areas, rare plants (*Arnica parryi*, *Aster xmaccallae*, *Braya humilis* var. *maccallae*, *Carex crawei*, *Crepis atrabarba*, *Draba ventosa*, *Haplopappus uniflorus*, *Osmorhiza chilensis*, *Pinus flexilis*, significant birds (American Bittern, Red-breasted Merganser, Bald Eagle, Barred Owl,

Black-backed Woodpecker, Rock Wren, House Wren, Western Flycatcher, Western Meadowlark, Tree Sparrow), spotted frogs, significant mammals (red fox, muskrat wolves), significant vegetation types (C1, C12, C26, O2, O11, H6) and Bird Communities (1,9,13), ungulate mineral licks, waterfowl nesting areas, and both prehistoric and historic cultural features.

7.2.17 Sawback Range

The Sawback Range natural area of significance extends from Mount Edith and Mount Cory to the Bow River, between Hillsdale and Fivemile Creek (Fig. 22). The area includes rare plants (*Draba albertina, Pellaea glabella, Ranunculus verecundus, Woodsia glabella*), significant vegetation types (C1, C16, C9, O5, H6, H7), rare birds (Long-eared Owl), significant Bird Communities (1,9,13) and mammals (muskrats), sheep, elk, deer, goat and moose winter range, waterfowl staging and nesting areas, and prehistoric cultural sites.

7.2.18 Scotch Camp

The Scotch Camp natural area of significance extends from Snow Creek Pass, north to the Red Deer River valley and east to the park boundary (Fig. 22). It contains hoodoos, permafrost on tracts of the SF1 Ecosite, Subalpine Chernozemic soils, Snowflake Lake which is of scientific interest, loess deposition areas, rare plants (*Carex bipartita, Carex deflexa, Draba longipes, Eriophorum callitrix, Ranunculus occidentalis, Salix boothii, Stellaria umbellata*), significant animals (Great Gray Owl, muskrat, cougar, wolf, grizzly bear), sheep and elk winter range, sheep summer range, ungulate mineral licks, significant Bird Communities (1,13) and vegetation types (C16, C26), and both prehistoric and historic cultural resource sites.

7.2.19 Siffleur River

The Siffleur River natural area of significance includes the watershed of the Siffleur River from Pipestone Pass and Clearwater Pass (including Devon Lakes) north to the park boundary (Fig. 22). It contains a significant vegetation type (C33), rare animals (Upland Sandpiper, fisher, caribou), ungulate mineral licks, elk winter range and historic features. This area contains the only woodland caribou in BNP.

7.2.20 Skoki

The Skoki natural area of significance is centered on Mount Skoki and includes Lake Merlin, Redoubt Lake, Baker Lake, Oyster Peak and the Red Deer Lakes area (Fig. 22). It contains a natural bridge, springs, rare plants (*Carex bipartita, Erysimum pallasii, Juncus parryi, Ranunculus grayi*), significant birds (Peregrine Falcon, Northern Phalarope, Cliff Swallow), significant mammals (wolverine, grizzly bear), goat winter range, a significant Ecosite (NG1) and historic features (Skoki Lodge, Cyclone cabin).

7.2.21 Spray Sixteen Mile

The Spray Sixteen Mile natural area of significance is on the west side of the Goat Range above the Spray River north of Sixteenmile cabin (Fig. 22). The area contains significant mammals (wolf, grizzly bear), elk fall and winter range, and sheep winter range.

7.2.22 Sulphur Mountain

The Sulphur Mountain natural area of significance occurs south of Cave Avenue and the Bow River, including the lower parts of Sundance Creek and the Spray River, and the northern end of Sulphur Mountain (Fig. 22). It contains many of the hot sulphur springs in BNP, rare plants (*Dicanthelium acuminatum, Pteridium aquilinum, Salix boothii*), rare invertebrates (*Physa johnsoni, Argia vivida*), a garter snake hibernaculum, spotted frogs, a rare fish (Banff Longnose Dace), Dipper winter habitat, significant Bird Communities (1,9), a wildlife migration corridor, deer and elk winter range, a significant Ecosite (PT3), and both prehistoric and historic sites.

7.2.23 Sunshine Meadows

The Sunshine Meadows natural area of significance extends from Fatigue Pass, north to Mount Bourgeau and west to Healy Pass and the Monarch Ramparts (Fig. 22). It contains a large number of rare plants (*Agrostis humilis, Agrostis thurberiana, Arenaria longipes, Arnica longifolia, Arnica parryi,*

Carex bipartita, Carex deflexa, Carex enanderi, Carex glacialis, Carex illota, Draba ventosa, Erigeron purpuratus, Erysimum pallasii, Hieracium cynoglossoides, Juncus parryi, Melica spectabilis, Mitella breweri, Poa lettermanii, Ranunculus verecundus, Rumex pauciflorus, Saxifraga flagellaris, Sparganium hyperboreum), rare mammals (water shrew, Richardson's water vole, wolverine) and birds (Peregrine Falcon), ungulate mineral licks, sheep summer and winter ranges, and historic sites.

7.2.24 Tunnel Mountain

The Tunnel Mountain natural area of significance extends from the Hoodoos Road and Tunnel Mountain to the base of Mount Rundle and east to the Cascade River, including the golf course (Fig. 22). It contains Bow Falls, hoodoos along the Bow River, rare plants (*Pellaea atropurpurea*), significant vegetation types (C1, O2, H6, H13), significant animals (long-toed salamander, Barred Owl, cougar) and Bird Communities (1,9,13), a wildlife migration corridor, black bear dens, elk and deer winter range, elk calving areas, Dipper winter habitat and prehistoric sites.

7.2.25 Vermilion Lakes

The Vermilion Lakes natural area of significance is bounded on the north by the Trans-Canada Highway from the industrial compound access road west to the Bow River bridge and then by the Bow River, west to include the Healy Creek backswamp. The southern boundary, from east to west, is along Whiskey Creek, the townsite limit, Cave Avenue, the old Healy Creek Road and the Trans-Canada Highway (Fig. 22). The area contains a large number and diversity of special features: lakes and ponds, springs, rare plants (*Salix boothii*), rare animals including a snail (*Physa johnsoni*), spotted frogs, garter snakes, long-toed salamanders, rare resident birds (American Bittern, Wood Duck, Bald Eagle, Barred Owl, Long-eared Owl, Magnolia Warbler, Red-necked Grebe, Pied-billed Grebe, Rusty Blackbird), rare migrant birds (Whistling Swan, Trumpeter Swan, Red Breasted Merganser, Golden Plover, Rough-legged Hawk, Wilson's Phalarope, Northern Phalarope, Franklin's Gull, Bonaparte's Gull, Sabine's Gull, Black Tern, Nashville Warbler, Palm Warbler), a significant Bird Community (9), significant mammals (pygmy shrew, muskrat, river otter), deer, elk and moose winter range, elk calving areas, ungulate mineral licks, waterfowl staging and nesting areas, and both prehistoric and historic cultural sites. It also contains one of the few areas of open water in winter and is especially important for winter resident birds. This portion of the Montane Ecoregion in the Bow Valley is an extremely valuable part of BNP and requires careful management to minimize adverse impacts from facility development and recreational activities.

7.2.26 Vermilion Pass

The Vermilion Pass natural area of significance extends from Vermilion Pass to Castle junction on either side of Altrude Creek (Fig. 22). It contains Altrude Canyon, rare plants (*Sorbus sitchensis*), rare animals (long-toed salamander, Hawk Owl, Lewis' Woodpecker, Black-backed Woodpecker) and historic sites. The birds are mainly in the Vermilion burn of 1968.

7.2.27 Ya Ha Tinda

The Ya Ha Tinda natural area of significance includes the area of the Ya Ha Tinda Ranch, east of the park boundary along the Red Deer River (Fig. 22). Although it is outside BNP, the Ya Ha Tinda because of its proximity and highly significant resources must be considered with BNP. It has not been as well studied as many parts of BNP but is known to contain several significant features, including Bighorn Falls, significant vegetation types (C16, H6), Bird Communities (1,9,13) and mammals (wolf), elk and sheep winter range, and prehistoric sites. The Ya Ha Tinda is part of the Montane Ecoregion which is the least extensive Ecoregion in BNP.

7.3 Management Considerations

The natural areas of significance described above are based on concentrations of special features without regard to threat or likelihood of disturbance. All are valuable and should receive special management consideration. However, to provide some management direction, they have been rated according to three degrees of threat (Table 8). Areas with a *high* degree of threat have been most heavily impacted by development and visitor use, are of easy access, and are prime areas for a continuing trend of increased park use and facility development. Areas with a *moderate* degree of threat have been at most moderately impacted, are of easy to moderately easy access, and are not prime areas for greatly increased use and development. *Low* threat areas are little, if any, impacted, are of moderately difficult to difficult access, and are unlikely to receive markedly increased use or facility development.

Table 8. Natural areas of significance and degree of threat.

High	Moderate	Low
2. Carrot Creek	1. Bow Lake	4. Castleguard Meadows
7. Hillsdale	3. Cascade-Flints Pk.	5. Clearwater River
8. Indian Grounds	6. Graveyard Flats	12. Marvel Lake
9. Johnston Canyon	11. L. Minnewanka	18. Scotch Camp
10. Lake Louise	14. Panther River	19. Siffleur River
13. Mount Norquay	20. Skoki	21. Spray Sixteen Mile
15. Parker Ridge	27. Ya Ha Tinda	26. Vermilion Pass
16. Saskatchewan Xg.		
17. Sawback Range		
22. Sulphur Mountain		
23. Sunshine Meadows		
24. Tunnel Mountain		
25. Vermilion Lakes		

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This study has systematically identified and described the special physical, biological and cultural resource features of BNP as far as is possible with current information. However, that information is inadequate in most cases. It serves to identify and describe, in general terms, the resource, its location and current status and, perhaps, to provide some broad management direction. But much more information is needed in greater detail, with greater locational accuracy and reliability, before specific management evaluations and actions can be done. For example, the current status of nearly all the biological features, except for some of the large mammals, is too poorly known to make a meaningful evaluation of their present status. Thus, the major conclusion of this study is that current *information* on special resources in BNP is grossly inadequate. Without adequate information, management cannot be well guided.

Current policy and many of the management recommendations in this report generally attempt to minimize adverse impacts on special features and areas. Ultimately, as use increases, limits to change will have to be established to prevent the gradual, incremental erosion of special features. Increased and more sophisticated monitoring will be needed to determine if such limits are being approached. The current summer use monitoring of the Sunshine Meadows (Achuff 1985, Harvey *et al.* 1985) is a first effort in such a program.

Along with the gathering of additional information through research and monitoring, the ability of the resource manager to update, retrieve and analyze that information in a timely manner must be improved. Current systems are slow, incomplete, often not current, and involve significant lag time. In short, an integrated, park-level, computer-based information system with adequate hardware, software and personnel support is needed. Rapid upgrading is required.

The sections below highlight some of the high priority features and areas which should receive special attention first. The Bow Valley Montane Ecoregion is most important (section 8.2). Some other important features and areas are in section 8.3. Section 8.4 discusses monitoring and research requirements, and section 8.5 deals with zoning.

8.2 Montane Ecoregion of the Bow Valley

In this analysis of special resources of BNP, the Bow Valley from approximately Johnston Creek to the east gate, all of which is in the Montane Ecoregion, has been found repeatedly to contain large numbers of special features in the physical, biological and cultural resource categories. This concentration of many, diverse features led to the recognition of nine natural areas of significance (section 7) in the lower Bow Valley — Carrot Creek, Indian Grounds, Tunnel Mountain, Mount Norquay, Sulphur Mountain, Vermilion Lakes, Sawback, Hillsdale and Johnston Canyon. All nine areas are subject to a high degree of threat (Table 8). This part of the Bow Valley is currently the most heavily developed and utilized portion of BNP and is likely to receive the greatest pressure from future development, whether from townsite expansion, more visitor facilities or upgrading of transportation routes. Some resources probably have already been strained beyond the breaking point; the Banff Longnose Dace is virtually extinct. Others, such as the animal migration corridors or the moose population, have apparently declined to a critical point. Our knowledge of many other resources is so scanty that a meaningful evaluation cannot be made.

Consequently, park resource managers are faced with a very difficult situation. The portion of BNP which contains the highest concentration of special resources is also that which has been most heavily impacted by human activity and which is most likely to be proposed for additional development and user impact. We can offer no panaceas for this dilemma. However, in view of the unparalleled diversity and number of special resources in the lower Bow Valley, protection of them should receive the highest priority. This will require innovative, careful management and constant vigilance.

Several resources in the Montane Ecoregion of the Bow Valley require a high priority in either management protection or further research and monitoring:

1. A thorough search should be made in springs and small streams for other populations of the Banff Longnose Dace (section 4.2.2).

2. Waterfowl use of the Vermilion Lakes and the effect of recreation should be studied and monitored (sections 4.2.4, 4.3.7, 4.3.8). Special emphasis on the Vermilion Lakes in the waterfowl monitoring program (Ledwidge 1984a) is needed.

3. Moose in the Bow Valley (section 4.2.5) are perhaps at a critical point. Research studies and continued monitoring are needed.

4. Little is known of black bear biology in the park (section 4.3.9). Research is needed on numbers, movements, habitat use and winter den sites.

5. Wildlife migration corridors around Banff townsite (section 4.3.6) are also at a critical state. Mitigative measures, including modification or relocation of the bison paddock, are needed.

6. Elk calving areas around Banff townsite (section 4.3.2) are threatened by proposed developments. This threat should be minimized and the effect of disturbance on the elk calving areas should be monitored.

8.3 Other areas and features

In addition to the features and areas dealt with in the preceding section, a number of other areas and features also should receive special attention.

8.3.1 Middle Springs

The Middle Springs are the only springs on Sulphur Mountain that have retained their natural character, although even they have been altered from their original condition (section 3.5.1). These springs should be preserved in their natural condition which may require zoning, land purchase, visitor control fences, and special interpretive activities.

8.3.2 Lakes

Many BNP lakes have already been altered from their natural conditions by recreational activity and facility development (section 3.5.3). Management principles for lakes (section 3.5.6) should include: 1) no additional facilities that attract visitors should be built, 2) existing facilities should be evaluated for improvement or relocation to reduce visitor impact, 3) recreational use of lakes should be evaluated to determine if the lakes can sustain current levels of use.

8.3.3 Rare Plants

Current information on the specific locations and population sizes of rare plants is very incomplete (section 4.1.1). Assessment of the environmental impact on rare plants by Phase III of the Trans-Canada Highway twinning will require more information than is presently available. A proper assessment must allow for field examination of affected sites by a professional botanist throughout the growing season.

8.3.4 Vegetation Communities

A number of forest (C1, C16, O2, O5) and grassland (H6, H7, H13, H19) vegetation types occupy small areas and are important to other species (section 4.1.3). Management should minimize any reduction or impairment of these special resources.

8.3.5 Ecological Land Classification Units

A number of Ecosites are of limited areal extent in BNP (section 5). Several occur in the lower Bow Valley and are covered above (section 8.2). However, VD2 and NT3 should also receive a high priority for protection. Only two of the eight tracts of VD2 in BNP are currently undisturbed and only two tracts of NT3 occur in the park. Disturbance of any of these tracts should be avoided, especially the undisturbed ones.

8.3.6 Siffleur Caribou Herd

The woodland caribou in the Siffleur River valley are the only ones in BNP (section 4.2.5). They should be protected from any disturbance or impairment of their habitat.

8.3.7 Sunshine Meadows

The Sunshine Meadows area contains a large number of rare and significant plant species (sections 4.1, 7.2.23). Increased summer visitor use of the meadows, currently about 30,000 visitors/season, may adversely impact some of these species which should receive the fullest protection possible. Current knowledge of both visitor impacts and plant locations is inadequate.

8.3.8 Prehistoric Sites

A number of prehistoric cultural resource areas have been identified as high priority for future investigation and preservation (section 6.3). These resources are nonrenewable and should receive careful management.

8.4 Monitoring and Research Recommendations

As stated above, current information on special resources in BNP is inadequate in many cases. This section selects a number of high priority resources that require additional monitoring or research studies.

8.4.1 Monitoring

Monitoring of selected natural resources of BNP is provided for by the Park Conservation Plan (Parks Canada 1985). The *Wildlife Monitoring Plan* (Jacobson and Kunelius 1983) provides for monitoring of some ungulates and carnivores on a systematic basis. Small mammals and birds, other than raptors and waterfowl, are monitored by random observations. Raptors and waterfowl are monitored every five years (Ledwidge 1984a,b). Forest tree insects which might become a management problem are monitored periodically as part of the vegetation management program (Parks Canada 1985). Control of non-native plants is provided for also (Parks Canada 1985), although no control measures have been taken. Fish monitoring is limited to sport species (Parks Canada 1985). Thus, small mammals and most birds are monitored only on a random basis, and most insects, plants and fish are not currently monitored in any way. In addition, a number of other programs are also monitoring various resource components, *e.g.* Sunshine Summer Use Plan, Trans-Canada Highway Twinning Impact assessment. Some of these activities provide partial information on special resource features, but there still remain sizeable information gaps for most features. Four special features require special monitoring and establishment of programs to monitor these features should receive high priority.

1. Long-toed salamanders (section 4.2.3) should be monitored periodically to determine their population and habitat status.

2. The garter snake hibernaculum (section 4.2.3) near the Cave and Basin should be located and monitored periodically to determine population and habitat trends.

3. Rare bird species (section 4.2.4), other than raptors and waterfowl, should be monitored on a systematic basis.

4. Monitoring of soil temperature on a number of permafrost and Subalpine Chernozemic soil sites (section 3.4) would be useful for a number of purposes.

The rationale for monitoring waterfowl and raptors only every five years (Ledwidge 1984a,b) is not clear and its purpose and effectiveness should be re-examined. Data points five years apart are unlikely to provide valid information on population trends or habitat utilization, particularly with the survey effort allotted to the project. More frequent and more intensive monitoring surveys are recommended.

The information gathered by the Bow Valley Naturalists during the Christmas Bird Count, the May count and other field activities should be incorporated into the park data base regularly. This information, particularly on birds, is a valuable supplement to warden wildlife observations.

8.4.2 Research Studies

Many special resources require research studies to begin to fill large knowledge gaps. Nine features have been chosen as being of high priority for future research efforts.

Hydrologic Resources: The inventory of hydrologic resources in BNP is incomplete (section 3.5.6). Research to complete this inventory should be started soon.

Castle Mountain Viewpoint Fossil Site: The Phase III twinning of the Trans-Canada Highway will affect this important fish fossil site (section 3.3). Salvage research both before and during the highway construction should be done to save as many fossils as possible.

Rare Plants: The specific location of most rare vascular plants (section 4.1.1) is not known and virtually nothing is known of the population size, detailed areal extent or life history of any of these species (section 4.1.1). Research studies should be begun to fill these information gaps. Species which have not been reported for more than 50 years should also be looked for. Additional research is also needed on non-vascular plants (section 4.1).

Fire Ecology: The fire ecology of the vegetation of BNP is a major factor in vegetation composition and dynamics, and in the habitat of many animals (sections 4.1.3, 4.2.5, 4.3). Research is needed to better understand the response of both vegetation and wildlife to various fire regimes in order to use fire properly as a means of managing special resources.

Invertebrates: No systematic inventory has been done of insects or other invertebrates in BNP (section 4.2.1). Research for such an inventory should be started to close this information gap. *Physa johnsoni*, in particular, needs to be studied more closely.

Bull Trout: Bull Trout appear to have declined rapidly in recent years (section 4.2.2). Research to determine their present status and habitat condition should be done soon.

Deer Winter Range: The numbers and seasonal movements of both mule deer and white-tailed deer in the Bow Valley are little understood. Research is needed on the population size, dynamics and seasonal location of both these species.

Ya Ha Tinda Ranch: The Ya Ha Tinda Ranch, although outside BNP, is administered by Parks Canada and contains many valuable features (section 7.2.27). A more complete resource inventory of the area should be conducted.

Prehistoric Cultural Sites: Additional research to locate and inventory prehistoric cultural sites is needed, especially in the Clearwater River, Siffleur River and North Saskatchewan River River valleys (section 6.3). Salvage work, for example in advance of Phase III of the Trans-Canada Highway twinning, should also be continued.

8.5 Zoning

Zoning offers a broad-scale tool for resource management and protection. This study has identified a large number of special resource features and areas. Many of these require the highest degree of management protection. In the current Parks Canada zoning (Parks Canada 1979), zones I (Special Preservation) and II (Wilderness) appear appropriate for many of the special resources in that they provide maximal protection. However, zoning must consider more than just the resource characteristics of the area under consideration. This report documents the characteristics of the special resources of BNP and suggest some priorities for management action among them, but the process of zoning must occur elsewhere. Thus, we will not attempt to make zoning recommendations for each feature and area identified as a special resource.

LITERATURE CITED

Achuff, P.L. 1978. Field notes in author's possession. Edmonton, Alberta.

Achuff, P.L. 1984a. Cardinal Divide area: resource description and comparison with other Rocky Mountain areas. Report to Alberta Energy and Natural Resources, Edmonton. 75 pp.

Achuff, P.L. 1984b. Field notes in author's possession. Edmonton, Alberta.

Achuff, P.L. 1985a. Beehive area: natural resources and management recommendations. Report to Alberta Forest Service, Alberta Energy and Natural Resources, Edmonton. 57 pp.

Achuff, P.L. 1985b. Vegetation monitoring, Sunshine Meadows, Summer 1985. Report to Parks Canada, Banff National Park. 35 pp.

Achuff, P.L. and G.M. Coen. 1980. Subalpine Cryosolic soils in Banff and Jasper National Parks. Canadian Journal of Soil Science 60: 579-581.

Achuff. P.L. and G.M. Coen. 1985. Permafrost and soil temperature regime in a subalpine forest. MS.

Achuff, P.L. and I.G.W. Corns. 1982. Vegetation. *In* W.D. Holland and G.M. Coen (gen. eds.), Ecological (biophysical) land classification of Banff and Jasper National Parks. Volume II: Soil and vegetation resources. Alberta Institute of Pedology Publication SS-82-44: 71-156.

Achuff, P.L. and I.G.W. Corns. 1985. Plants new to Alberta from Banff and Jasper National Parks. Canadian Field-Naturalist 99: 94-98.

Achuff, P.L. and H.A. Dudynsky. 1984a. Vegetation. *In* P.L. Achuff, W.D. Holland, G.M. Coen and K. Van Tighem (eds.), Ecological land classification of Kootenay National Park, British Columbia. Volume I: Integrated resource description. Alberta Institute of Pedology Publication M-84-10: 43-131.

Achuff, P.L. and H.A. Dudynsky. 1984b. Vegetation. *In* P.L. Achuff, W.D. Holland, G.M. Coen and K. Van Tighem (eds.), Ecological land classification of Mount Revelstoke and Glacier National Parks, British Columbia. Volume I: Integrated resource description. Alberta Institute of Pedology Publication M-84-11: 33-83.

Achuff, P.L., W.D. Holland, G.M. Coen and K. Van Tighem (eds.). 1984. Ecological land classification of Kootenay National Park, British Columbia. Volume I: Integrated resource description. Alberta Institute of Pedology Publication M-84-10: 373 pp.

Alberta Fish and Wildlife. 1984. Status of the Fish and Wildlife Resource in Alberta. Alberta Energy and Natural Resources, Edmonton. 123 pp.

Alberta Forestry Association. 1984. Alberta trees of renown. Alberta Forestry Association, Edmonton. 32 pp.

Anderson, R. 1970. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Anderson, R. 1975. Site reports - Lake Louise archaeological survey. File report, Archaeological Research Unit, Parks Canada, Calgary, Alberta.

Anderson, R.M. 1938. Investigations into the wildlife conditions in national parks (Waterton Lakes, Banff and Jasper) in the province of Alberta, 1938. File report, Department of Mines and Resources, Lands, Parks and Forests Branch. 13 pp.

Anderson, R.S. 1968. The limnology of Snowflake Lake and other high altitude lakes in Banff National Park, Alberta. PhD thesis, University of Calgary, Calgary, Alberta. 218 pp.

Anderson, R.S. 1969a. Limnological studies of high altitude lakes in the national parks of western Canada. IV. Aspects of the physical and chemical limnology of a large number of lakes in Banff National Park. Canadian Wildlife Service, Calgary, Alberta. 82 pp.

Anderson, R.S. 1969b. Limnological studies of high altitude lakes in the national parks of western Canada. V. Limnological investigations in Herbert Lake, Banff National Park, Alberta. Canadian Wildlife Service, Calgary, Alberta. 58 pp.

Anderson, R.S. 1970. Physical and chemical limnology of two mountain lakes in Banff National Park, Alberta. Journal of the Fisheries Research Board of Canada 27: 233-249.

Anderson, R.S. and D.B. Donald. 1978. Limnological survey of some small lakes in the vicinity of the Cascade Trail, Banff National Park. Canadian Wildlife Service, Calgary, Alberta. 162 pp.

AOU (American Ornithologists' Union). 1983. Checklist of North American birds, sixth edition. AOU Committee on Classification and Nomenclature.

Argus, G.W. and D.J. White. 1978. The rare vascular plants of Alberta. Syllogeus 17: 46 pp.

Atkinson, T.C. 1983 Growth mechanisms of speleotherms in Castleguard Cave, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research 15: 523-536.

Baird, D.M. 1977. Banff National Park: How nature carved its splendour. Hurtig Publishers, Edmonton. 237 pp.

Banfield, A.W.F. 1958. The mammals of Banff National Park, Alberta. National Museum of Canada Bulletin 159.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press. 438 pp.

Baranowski, S. and W.E.S. Henoch. 1978. Glacier and landform features in the Columbia Icefield area, Banff and Jasper national parks, Alberta, Canada. Environment Canada, Inland Waters Directorate, Ottawa, Ontario. 157 pp.

Beckstead, G.R.E. 1980. Banff floodplain study. Alberta Environment, Edmonton. 20 pp.

Beebe, 1974. Field studies of the Falconiformes of British Columbia. British Columbia Provincial Museum Occasional Paper 17: 163 pp.

Behler, J.L. and F.W. King. 1979. The Audubon field guide to North American reptiles and amphibians. Chanticleer Press, New York. 719 pp.

Behnke, R.J. 1979. Monograph of the native trouts of the genus *Salmo* in western North America. PhD thesis, University of California, Berkeley.

Bobek, B., R. Kunelius and J. Weiner. 1979. Energy balance and population structure of elk (*Cervus canadensis*) in Banff National Park. Faculty of Environmental Design, University of Calgary and Warden Service, Banff National Park. 26 pp.

Block, H.O. and W.D. Gummer. 1979. Bacteriological and nutrient study of major surface waters in Banff National Park. Environment Canada, Water Quality Branch, Calgary, Alberta. 60 pp.

Bone, P.T. 1947. When the steel went through. MacMillan of Canada, Toronto. 180 pp.

Bow Valley Naturalists. 1978. Vermilion Lakes, Banff National Park: an introductory study. Bow Valley Naturalists, Banff, Alberta. 68 pp.

Bowman, T.E. 1975. Three new troglobitic asellids from western North America (Crustacea: Isopoda: Asellida). International Journal of Speleology 7: 339-356.

Brinkman, D. 1986. letter to the author. Tyrrell Museum of Palaeontology, Drumheller, Alberta.

Broughton, P.L. 1972. Secondary mineralisation in the cavern environment. Studies in Speleology 2: 191-207.

Brown, W. 1986. personal communication. Warden Service, Banff National Park.

Brown, W. and J. Wackerle. 1985. Monitoring program mitigation measures, Trans-Canada Highway twinning, phase I, km 0-11.4, Second Progress Report. File report, Warden Service, Banff National Park. 56 pp.

Butler, J.R. and R.R. Maw. 1985. Fishing Canada's Mountain Parks. Lone Pine Publishing, Edmonton, Alberta. 126 pp.

Byrne, A.R. 1964. Man and landscape change in the Banff National Park area before 1911. *In* Land Use History and Landscape Changes, National Park Series 1: 25-28.

CanSIS (Canada Soil Information System). 1981. Map index linkages for Banff-Jasper ecological land classification maps. Land Resource Research Institute, Agriculture Canada, Ottawa.

Carbyn, L. 1974. Wolf predation and behavioural interactions with elk and other ungulates in an area of high prey diversity. File report, Canadian Wildlife Service, Edmonton, Alberta.

Cathey, J.D. 1976. Unique and significant features of the Bow Valley corridor, Banff National Park. Report to Parks Canada, Calgary. 74 pp.

Chadwick, D.H. 1983. The beast the color of winter: the mountain goat observed. Sierra Club Books, San Francisco.

Christensen, O.A. 1971. Banff prehistory: prehistoric subsistence and settlement in Banff National Park, Alberta. National Historic Sites Service, Manuscript Report 17: 279 pp.

CITES (Convention on International Trade in Endangered Species). 1984. Control list number 6. Environment Canada, Canadian Wildlife Service, Ottawa. 69 pp.

Clarke, C.H.D. 1940. Wildlife investigation in Banff National Park, 1939. File report, Canadian National Parks Bureau. 26 pp.

Clarke, C.H.D. 1942. Wildlife investigations in Banff and Jasper national parks. File report, Canadian National Parks Service. 38 pp.

Clarke, A.H. 1973. The freshwater molluscs of the Canadian inner basin. Malacologia 13: 509 pp.

Clarke, A.H. 1976. The endangered mollusks of Canada. *In* T. Mosquin and C. Suchal (eds.), Canada's threatened species and habitats. Canadian Nature Federation and World Wildlife Fund, Ottawa. pp. 148-150.

Clarke, A.H. 1981. The freshwater mollusks of Canada. National Museum of Natural Sciences, Ottawa, Ontario.

Clarkson, P. 1982. Boundary area wildlife: status and concerns in Banff, Jasper, Kootenay and Yoho national parks. Four Mountain Parks Planning Program, Parks Canada, Calgary.

Clifford, H.F. and G. Bergstrom. 1976. The blind aquatic isopod *Salmasellus* from a cave spring in the Rocky Mountains' eastern slopes, with comments on a Wisconsin refugium. Canadian Journal of Zoology 54: 2028-2032.

Cockerton, D. 1978. Lake Louise land use history. File report, Parks Canada, Calgary, Alberta. 47 pp.

Coen, G.M. and P.L. Achuff. 1985. Soil and air temperatures in mountain grassland environments. MS prepared for 1986 International Soil Science Congress, Hamburg, Germany.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 1985. COSEWIC designated species list (April 1985). Environment Canada, Canadian Wildlife Service, Ottawa. 5 pp.

Cowan, I.M. and V.C. Brink. 1949. Natural game licks in the Rocky Mountain national parks of Canada. Journal of Mammalogy 30: 379-387.

CSSC (Canada Soil Survey Committee). 1978. The Canadian system of soil classification. Agriculture Canada Publication 1646: 164 pp.

Cuerrier, J.P. 1954. The history of Lake Minnewanka with reference to the reaction of lake trout to artificial changes in environment. Canadian Wildlife Service, Ottawa, Ontario.

Dalke, P.D., R.B. Beeman, F.J. Kindel, R.J. Robel and T.R. Williams. 1965. Use of salt by elk in Idaho. Journal of Wildlife Management 29: 319-332.

Damp, J.E., C.E. Connolly and T.V. Smith. 1980. Conservation archaeological studies at EhPw-2 and EhPw-4, Banff National Park. Report to Parks Canada, Calgary, Alberta by Lifeways of Canada Ltd. 139 pp.

Davidson, T. 1985a. Waterfowl survey, Banff National Park 1984. File report, Warden Service, Banff National Park.

Davidson, T. 1985b. Raptor survey, Banff National Park 1984. File report, Warden Service, Banff National Park.

Department of the Interior. 1902. Annual Report. Queen's Printer, Ottawa, Ontario.

Department of the Interior. 1921. Annual Report. Queen's Printer, Ottawa, Ontario.

Department of the Interior. 1932. Annual Report. Queen's Printer, Ottawa, Ontario.

Elliot, J. 1970. Site reports. File report, Archaeological Section, Parks Canada, Calgary, Alberta.

Elliot, S. 1970. Site reports. File report, Archaeological Section, Parks Canada, Calgary, Alberta.

Environment Canada. 1974. Historical streamflow summary: Alberta to 1973. Inland Waters Directorate, Calgary, Alberta.

Epler, A.M. 1985. Historic buildings inventory - Banff townsite. Alberta Culture, Historic Sites Service. 81 pp.

Fedje, D. 1982a. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Fedje, D. 1982b. Preliminary excavations of the Whiskey Creek site — EhPv-24, Banff National Park. Archaeological Research Section, Parks Canada, Calgary, Alberta. 46 pp.

Fedje, D. 1983. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Fedje, D. 1984. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Fedje, D. 1985a. Archaeological investigations in Banff National Park - 1983. Parks Canada Research Bulletin 236: 25 pp.

Fedje, D. 1985b. personal communication. Archaeological Research Section, Parks Canada, Calgary, Alberta.

Fedje, D. 1986. Banff archaeology 1983-1986. MS. Archaeological Research Section, Parks Canada, Calgary, Alberta. 40 pp.

Field, W.O. and C.J. Heusser. 1953. Glacier and botanical studies in the Canadian Rockies — 1953. Canadian Alpine Journal 37: 127-140.

Flygare, H. 1978. Wildlife mortality statistics highways and railroad 1964-1977. File report, Warden Service, Banff National Park. 55 pp.

Ford, D.C. 1968. Report to the National and Historic Parks Branch, contract 867.

Ford, D.C. 1969. Geomorphology of the Mount Castleguard area, Banff National Park. Report to National and Historic Parks Branch, Ottawa. pp. 45-46.

Ford, D.C. 1973. Final report upon a winter expedition to Castleguard Cave, Banff National Park. Cave and Karst Research Group of Canada, report to Parks Canada, Ottawa. 18 pp.

Ford, D.C. 1983. Physiography of the Castleguard karst and Columbia Icefields area, Alberta, Canada. Arctic and Alpine Research 15: 427-436.

Fraser, E. 1969. The Canadian Rockies - early travels and explorations. Hurtig, Edmonton. 252 pp.

Freisen, R. 1985. Banff, Jasper, Kootenay and Yoho National Parks, outlying historical building data base. Historical Architecture Section, Parks Canada, Calgary, Alberta.

Frison, G.C. 1978. Prehistoric hunters of the High Plains. Academic Press, New York.

Fyfe, R.W and R.R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Canadian Wildlife Service Occasional Paper 23.

Gardner, D. 1975. North West Mounted Police Outposts in southern Alberta — 1874 to 1904. File report, Alberta Culture, Historic Sites Service, Edmonton.

Gardner, J.S. 1968. Debris slope form and processes in the Lake Louise district: a high mountain area. PhD thesis, McGill University, Montréal, Québec. 263 pp.

Gascoyne, M., A.G. Latham, R.S. Harmon and D.C. Ford. 1983. The antiquity of Castleguard Cave, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research 15: 463-470.

Gest, L. 1970. History of Moraine Lake. privately published. 39 pp.

Godfrey, W.E. 1966. The Birds of Canada. National Museums of Canada Bulletin 203: 428 pp.

Gordon, B. 1975. Status of birds, Banff National Park. Canadian Wildlife Service report to Warden Service, Banff National Park. 224 pp.

Green, H.U. 1949. The bighorn sheep of Banff National Park. File report, Warden Service, Banff National Park. 88 pp.

Green, H.U. 1951. The wolves of Banff National Park. Canada Department of Resources and Development, National Parks Branch.

Green, H.U. 1955a. The wolves of Banff National Park: supplementary notes. File report, Warden Service, Banff National Park.

Green, H.U. 1955b. Wildlife notes (February). File report, Warden Service, Banff National Park.

Green, H.U. 1955c. Wildlife notes (April). File report, Warden Service, Banff National Park.

Green, H.U. 1956. Notes on the trapping, biology and behavior of the wolverine. File report, Warden Service, Banff National Park. 14 pp.

Green, H.U. 1957. The occurrence, distribution and population of mammals, Banff National Park, Alberta. File report, National Parks Branch, Ottawa.

Haites, T.B. 1959. Banff thermal springs, a fascinating problem. Journal of the Alberta Society of Petroleum Geology 7: 23-32.

Hamer, D. and S. Herrero (eds.). 1983. Ecological studies of the grizzly bear in Banff National Park. University of Calgary, Calgary, Alberta. 431 pp.

Harris, J.G. 1985. A revision of the genus *Braya* (Cruciferae) in North America. PhD thesis, University of Alberta, Edmonton. 250 pp.

Harrison, G., R. Hooper and P. Jacobson. 1982. Ungulate population statistics and habitat analysis, Banff National Park (east gate to Sunshine turn-off). File report, Parks Canada, Calgary. 87 pp.

Hart, E.J. 1979. Diamond hitch: the early outfitters and guides of Banff and Jasper. Summerthought, Banff, Alberta. 160 pp.

Hartland-Rowe, R. and R.S. Anderson. 1968. An arctic fairy shrimp (*Artemiopsis stefanssoni* Johansen 1921) in southern Alberta, with a note on the genus *Artemiopsis*. Canadian Journal of Zoology 46: 423-425.

Harvey, D.C., A.W. Westhaver and R. Thompson. 1985. Sunshine Meadows summer use monitoring programme, final report 1985. File report, Warden Service, Banff National Park. 56 pp.

Jacobson, P.C. 1976. Status of goats in Banff National Park. File report, Warden Service, Banff National Park. 8 pp.

Jacobson, P.C. 1979. Status of caribou in Banff National Park (1976). Parks Canada, Natural Resources Bulletin 3: 2-3.

Jacobson, P.C. (ed.) 1980. Preliminary survey for grizzly bear habitat in the vicinity of the Lake Louise ski area. File report, Warden Service, Banff National Park. 37 pp.

Jacobson, P.C. 1981. Bourgeau sheep range: preliminary report. File report, Warden Service, Banff National Park. 10 pp.

Jacobson, P.C. 1986. personal communication. Warden Service, Banff National Park.

Jacobson, P.C. and R. Kunelius. 1983. Wildlife monitoring plan. File report, Warden Service, Banff National Park. 42 pp.

Jacobson, P.C. and D. Loewen. 1980. Distribution and abundance of goats in the Slate Range area. File report, Warden Service, Banff National Park. 40 pp.

Jalkotzy, M. 1980. River otter reintroduction feasibility study. Alberta Recreation and Parks, Kananaskis Country Planning Document 8: 45 pp.

Jalkotzy, M., O. Pall and J. Kansas. 1984. Population status of cougar near Sheep River, Alberta, 1983-1984 Progress Report. File report, Alberta Fish and Wildlife, Calgary. 40 pp.

Janz, B. and D. Storr. 1977. The climate of the contiguous mountain parks: Banff, Jasper, Yoho, Kootenay. Environment Canada, Atmospheric Environment Service, Meteorological Applications Branch Project Report 30.

Johnson, R.L. 1977. Distribution, abundance and management of mountain goats in North America. *In* W. Samuel and W.G. Macgregor (eds.), Proceedings of the First International Mountain Goat Symposium, British Columbia Ministry of Recreation and Conservation. pp. 1-7.

Jones, R.L. and H.C. Hanson. 1985. Mineral licks, geophagy and biochemistry of North American ungulates. Iowa State University Press, Ames. 301 pp.

Jozsa, L.A., S.G. Johnson and P.A. Bramhall. 1984. X-ray densitometric analysis of an old Douglas fir stand from Banff, Alberta. Forintek Canada Corp., Vancouver, British Columbia report to Department of Forest Science, University of Alberta. 47 pp.

Karasiuk, D. no date. A review of wildlife observational data 1944-1971. File report, Banff National Park. 60 pp.

Kaye, R.G. and J.M. Roulet. 1980. The distribution and status of wolves. Four Mountain Parks Planning Program, Parks Canada, Calgary, Alberta. 17 pp.

Leeson, B. 1984. Banff townsite peripheral land use initial environmental evaluation. Interim Report 11. Parks Canada, Calgary, Alberta.

Leeson, B. 1985. personal communication. Parks Canada, Western Regional Office, Calgary, Alberta.

Leonard, M.E. 1981. Glaciolacustrine sedimentation and Holocene glacial history, northern Banff National Park. PhD thesis, University of Colorado, Boulder. 271 pp.

MacIsaac, D. 1985. personal communication. Department of Botany, University of Alberta, Edmonton.

Marsh, A.H. 1974. The botany and natural history of Middle Springs Swamp, Banff, Alberta. Canadian Field-Naturalist 88: 129-140.

Mayhood, D.W. and R.S. Anderson. 1976. Limnological survey of the Lake Louise area, Banff National Park. Part 1. Canadian Wildlife Service, Calgary, Alberta. 23 pp.

McAllister, D.E. 1986. personal communication. National Museum of Natural Sciences, Ottawa, Ontario.

McAllister, D.J., F.W. Allendorf and S.R. Phelps. 1981. An analysis of the native and resident cutthroat trout (*Salmo clarki*) in the Bow, Kootenay-Columbia and Waterton river systems. Report to Parks Canada, Calgary by Techman Engineering Limited, Calgary. 98 pp.

McCrory, W.P. 1965. Preliminary report on the study of natural licks used by mountain goats and bighorn sheep in Jasper National Park. File report, Canadian Wildlife Service, Edmonton. 55 pp.

McCrory, W.P. 1967. Absorption and excretion by mountain goats of minerals found in a natural lick. File report, Canadian Wildlife Service, Edmonton. 22 pp.

McDonald, B.C. and I. Banerjee. 1971. Sediments and bedforms on a braided outwash plain. Canadian Journal of Earth Science 8: 1282-1301.

McDonough, D. 1983. Banff National Park toxic spill management plan. File report, Warden Service, Banff National Park. 28 pp.

McFetridge, R.J. 1977. Strategy of resource use by mountain goats in Alberta. MSc thesis, University of Alberta, Edmonton.

Meier, M.F. 1960. Mode of flow of Saskatchewan Glacier, Alberta. U.S. Geological Survey Professional Paper 351: 70 pp.

McIntyre, M.L. and B.O.K. Reeves. 1975. Archaeological investigations, Lake Minnewanka site (EhPu-1). File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

McIvor, M. 1986. personal communication. Bow Valley Naturalists, Banff, Alberta.

McLauchlan, W. 1985. personal communication. trapper, Olds, Alberta.

Mickle, D. 1985. personal communication. Warden Service, Banff National Park.

Morgantini, L.E. 1978. Ecology and behavior of the Banff-Ya Ha Tinda elk herd and the effects of harassment. Department of Animal Science, University of Alberta report to Parks Canada, Calgary and Banff National Park. 21 pp.

Morgantini, L.E. 1984. Elk in the Canadian Rocky Mountains: The Panther-Red Deer-Clearwater region in Banff National Park. Report to Warden Service, Banff National Park. 72 pp.

Morgantini, L.E. and R.J. Hudson. 1983. Nutritional significance of altitudinal migrations for wapiti. University of Alberta Agriculture and Forestry Bulletin, Special Issue, 62nd Feeder's Day Report, pp. 109-112.

Morris, R.L. and W.W. Tanner. 1969. The ecology of the Western Spotted Frog, *Rana pretiosa pretiosa*, Baird & Girard: a life history study. Great Basin Naturalist 19: 45-81.

Mudry, D.R. and R.B. Green. 1977. Limnological investigations on Sunshine, Healy and Brewster creeks, Banff National Park during 1976. Bio-systems, Calgary, Alberta report to Parks Canada, Calgary. 69 pp.

Mueggler, W.F. and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA Forest Service, General Technical Report INT-66: 154 pp.

Neilsen, P.L. 1973. The mammals of Waterton Lakes National Park, Alberta. Canadian Wildlife Service report to Parks Canada, Calgary, Alberta. 176 pp.

Neilson, G. 1975a. Groundwater potential of Banff National Park. Hydrogeological Consultants Ltd., Calgary, Alberta report to Parks Canada, Calgary. 21 pp.

Neilson, G. 1975b. Groundwater supply for a proposed fish hatchery: Phase II. Hydrogeological Consultants Ltd., Calgary, Alberta report to Parks Canada, Calgary. 40 pp.

Nelson, J.S. 1983. The tropical fish fauna in Cave and Basin Hotsprings drainage, Banff National Park. Canadian Field-Naturalist 97: 255-261.

Nichols, J.T. 1916. On a new race of minnow from the Rocky Mountains Park. Bulletin of the American Museum of Natural History 35: 69.

Noble, L.B. 1972. Man and grizzly bear in Banff National Park, Alberta. MSc thesis, University of Calgary, Calgary, Alberta.

Olson, W.E. 1984. Banff townsite peripheral land use, Wildlife Component, Initial Environmental Evaluation. Warden Service, Banff National Park. 132 pp.

Ommanney, C.S.L. 1972. Glacier surveys by district personnel of the Water Survey of Canada. 2. The Peyto Glacier. Department of the Environment (Ottawa), Inland Waters Directorate, Glacier Inventory Note 7: 20 pp.

Ommanney, C.S.L, J. Clarkson and M.M. Strome. 1973. Information booklet for the inventory of Canadian glaciers. Department of the Environment (Ottawa), Inland Waters Directorate, Glacier Inventory Note 4: 78 pp.

Ozaray, G.F. and R. Barnes. 1978. Hydrogeology of the Calgary-Golden area, Alberta. Alberta Research Council Report 77-2: 38 pp.

Packer, J.G. 1983. Flora of Alberta. Second Edition. University of Toronto Press, Toronto. 687 pp.

Packer, J.G. and C.E. Bradley. 1984. A checklist of the rare vascular plants in Alberta. Provincial Museum of Alberta, Natural History Occasional Paper 5: 112 pp.

Parks Canada. 1977. Bow River — a description and evaluation of recreational potential for canoeing and kayaking. Western Regional Office, Natural History Research Division, Calgary, Alberta. 98 pp.

Parks Canada. 1978a. The Bow River, Banff National Park — recreation management guidelines for canoeing and kayaking. Western Regional Office, Natural History Research Division, Calgary, Alberta. 27 pp.

Parks Canada. 1978b. The North Saskatchewan River — a description and evaluation of recreational potential for canoeing and kayaking. Western Regional Office, Natural History Research Division, Calgary, Alberta. 81 pp.

Parks Canada. 1979. Parks Canada Policy. Ottawa. 69 pp.

Parks Canada. 1984. Banff townsite peripheral land use, Initial Environmental Evaluation (Interim Report II). Natural History Research Division, Calgary, Alberta, 35 pp.

Parks Canada. 1985. Park Conservation Plan. Banff National Park.

Pearson, A.M. 1975. The northern interior grizzly bear (*Ursus arctos* L.). Canadian Wildlife Service Report Series 3: 86 pp.

Perren, P. 1982. Banff National Park Resource Management and Public Safety. Four Mountain Parks Planning Program, Parks Canada, Calgary, Alberta. 92 pp.

Petocz, R.G. 1973. The effect of snow cover on the social behavior of bighorn rams and mountain goats. Canadian Journal of Zoology 51: 987-993.

Pfister, R.D., B.L. Kovalchik, S.F. Arno and R.C. Presby. 1977. Forest habitat types of Montana. USDA Forest Service General Technical Report INT-34: 174 pp.

Poll, D.M., M.M. Porter, G.L. Holroyd, R.M. Wershler and L.W. Gyug. 1984. Ecological land classification of Kootenay National Park, British Columbia. Volume II: Wildlife resource. Canadian Wildlife Service report to Parks Canada, Calgary, Alberta. 260 pp.

Porsild, A.E. 1959. Botanical excursion to Jasper and Banff National Parks, Alberta: alpine and subalpine flora. National Museum of Canada, Ottawa. 38 pp.

Porter, J.E.H. 1979. Archaeology of Johnson Lake site 20R (EhPu-6). File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Porter, J.E.H. 1981. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Porter, J.E.H. 1982. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Porter, J.E.H. 1983. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Porter, J.E.H. 1984. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Pritchard, G. 1971. *Argia vivida* Hagen (Odonata:Coenagrionidae) in hot pools at Banff. Canadian Field-Naturalist 85: 186-188.

Pritchard, G. 1980. The life cycle of *Argia vivida* Hagen in the northern part of its range (Zygoptera:Coenagrionidae). Odonatologia 9: 101-106.

Pritchard, G. and B. Pelchat. 1977. Larval growth and development of *Argia vivida* (Odonata:Coenagrionidae) in warm sulphur pools at Banff, Alberta. Canadian Entomologist 109: 1563-1570.

Pugsley, C.W. 1983. The fauna of Castleguard Cave. Paper presented at National Speleological Society meeting, Elkins, West Virginia.

Rawson, D.S. 1939. A biological survey and recommendation for fisheries management in waters of Banff National Park. Department of Mines and Resources, National Parks Bureau, Ottawa, Ontario. 128 pp.

Rawson, D.S. 1942. The effect of the 1941 power development on the fisheries of Lake Minnewanka, Banff National Park. Department of Mines and Resources, National Parks Bureau, Ottawa, Ontario. 26 pp.

Rawson, D.S. 1945. Further investigation of the effect of power development on the fisheries of Lake Minnewanka, Banff National Park. Department of Mines and Resources, National Parks Bureau, Ottawa, Ontario. 54 pp.

Raymond, P.E. 1925. Two new fossil fishes from Alberta. American Journal of Science, 5th series, 209: 551-555.

Reeves, B.O.K. 1969. The southern Alberta paleocultural and paleoenvironmental sequence. *In* Post-Pleistocene Man and his Environment on the Northern Plains, University of Calgary Archaeological Association, pp. 6-46.

Reeves, B.O.K. 1972. An inventory of archaeological sites in Banff National Park and the Ya Ha Tinda horse ranch. Department of Archaeology, University of Calgary, 112 pp.

Reeves, B.O.K. 1976. 1975 archaeological investigations, Lake Minnewanka site (EhPu-1). File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Reeves, B.O.K: 1981. The Rocky Mountain Eastern Slopes: problems and considerations. *In* T.A. Moore (ed.), Alberta Archaeology: Prospect and Retrospect, Archaeological Society of Alberta, Lethbridge, 108 pp.

Reilly, R. and R. Beardmore. 1980. Waterfalls of Canada — a natural history theme study. Parks Canada, Ottawa, Ontario. 149 pp.

Renaud, C.B. and D.E. McAllister. 1985. Taxonomic status of the Banff Longnose Dace *Rhinichthys cataractae smithii* Nicholls, 1916, of Banff National Park. MS, 23 pp.

Roberge, J. and D. Caron. 1983. The occurrence of an unusual type of pisolite: the cubic cave pearls of Castleguard Cave, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research 15: 517-522.

Robinson, B. 1973. Banff Springs: the story of a hotel. Summerthought, Banff. 117 pp.

Robinson, D.J. and R.E. Smith. 1974. Limnological study of the Bow River - Pipestone River watershed in the vicinity of Lake Louise, Banff National Park. Limnos Associates, Calgary, Alberta report to Parks Canada, Calgary. 154 pp.

Russell, L.S. 1951. *Bobasatrania canadensis* (Lambe), a new giant chondrostean fish from the Rocky Mountains. National Museum of Canada Bulletin 123.

Russell, R.H., J.W. Nolan, N.G. Woody and G.H. Anderson. 1979. A study of the grizzly bear in Jasper National Park, 1975-1978. Canadian Wildlife Service Report to Parks Canada, Calgary. 136 pp.

Rutter, N.W. 1972. Geomorphology and multiple glaciation in the area of Banff, Alberta. Geological Survey of Canada Bulletin 206: 54 pp.

Salt, W.R. and J.R. Salt. 1976. The birds of Alberta. Hurtig Publishers, Edmonton. 498 pp.

Scace, R.C. 1968. Banff: a cultural-historical study of land use and management in a national park community to 1945. Studies in Land Use and Landscape Change, National Parks Series 2: 154 pp.

Schaeffer, B. and M. Mangus. 1976. An early Triassic fish assemblage from British Columbia. Bulletin of the American Museum of Natural History 156: 515-564.

Schmidt, K.P. and J.R. Gunson. 1985. Evaluation of wolf-ungulate predation near Nordegg, Alberta. File report, Alberta Fish and Wildlife Division, Edmonton.

Schowalter, D.B. 1976. Bat rabies in Alberta. Alberta Fish and Wildlife Division, Edmonton. 12 pp.

Schroeder, J. and D.C. Ford. 1983. Clastic sediments in Castleguard Cave, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research 15: 451-461.

Scotter, G.W. and J.J. Hudson. 1975. *Carex illota* L.H. Bailey in Alberta. Canadian Field-Naturalist 89: 74-75.

Skjonsberg, T. 1985a. Eastern slopes wildlife study progress report. File report, Warden Service, Banff National Park. 40 pp.

Skjonsberg, T. 1985b. personal communication. Warden Service, Banff National Park.

Smart, C.C. 1983. The hydrology of the Castleguard karst, Columbia Icefields, Alberta, Canada. Arctic and Alpine Research 15: 471-486.

Smith, B.L. 1977. Influence of snow conditions on winter distribution, habitat use and group size of mountain goats. *In* W. Samuel and W.G. Macgregor (eds.), Proceedings of the First International Mountain Goat Symposium, British Columbia Ministry of Recreation and Conservation. pp. 174-189.

Smith, D.G. 1973. Aggradation and channel braiding in the North Saskatchewan River, Alberta, Canada. PhD thesis, Johns Hopkins University, Baltimore, Maryland. 85 pp.

Smith, N.D. 1975. Sedimentary environment and late Quaternary history of a *low-energy* mountain delta. Canadian Journal of Earth Science 12: 2004-2013.

Smith, N.D. 1978. Sedimentary processes and patterns in a glacier-fed lake with low sediment input. Canadian Journal of Earth Science 15: 741-756.

Sole, A. 1980. Waterfall ice. Rocky Mountain Books, Calgary, Alberta. 92 pp.

Soper, J.D. 1941. History, range and home life of the northern bison. Ecological Monographs 11: 347-412.

Soper, J.D. 1964. The mammals of Alberta. Queen's Printer, Edmonton, Alberta.

Soper, J.D. 1967. The mammals of Waterton Lakes National Park, Alberta. Canadian Wildlife Service report to Parks Canada. 141 pp.

Stelfox, J., P. Kuchar and J.A. Bindernagel. 1978. Range ecology of mountain caribou (*Rangifer tarandus caribou*), Jasper National Park, 1971-1974. File report, Canadian Wildlife Service, Edmonton. 121 pp.

Sumpter, I. 1984. Site reports. File report, Archaeological Research Section, Parks Canada, Calgary, Alberta.

Tate, J. and D.J. Tate. 1982. The Blue List for 1982. American Birds 36: 126-135.

Tera. 1982. Regional analysis of Natural Region 5: the Rocky Mountains. Tera Environmental Consultants Ltd., Vancouver, British Columbia report to Parks Canada. 3 volumes.

Thompson, P. 1976. Cave exploration in Canada. Canadian Caver Magazine, Department of Geography, University of Alberta, Edmonton.

Trottier, G.C. 1977. Some aspects of backcountry use in Banff National Park. Canadian Wildlife Service, Edmonton, Alberta. 78 pp.

Utzig, G.F., P.G. Comeau, O.L. Macdonald, M.V. Ketcheson, T.F. Braumandl, A.R. Warner and G.W. Still. 1983. A field guide for identification and interpretation of ecosystems in the Nelson Forest Region. British Columbia Ministry of Forests, Nelson. 75 pp.

van Everdingen, R.O. 1969. The Ink Pots — a group of karst springs in the Rocky Mountains near Banff, Alberta. Canadian Journal of Earth Science 6: 545-544.

van Everdingen, R.O. 1972. Thermal and mineral springs in the southern Rocky Mountains of Canada. Department of the Environment (Ottawa), Water Management Service. 151 pp.

van Everdingen, R.O. 1978. Sulphur Mountain hot springs — information document. Environment Canada, Hydrology Research Division, Calgary, Alberta. 77 pp.

Van Kirk, S.M. 1969. The development of national park policy in Canada's mountain national parks. MA thesis, University of Alberta, Edmonton.

Van Tighem, K. and L.W. Gyug. [1984]. Ecological land classification of Mount Revelstoke and Glacier National Parks, British Columbia. Volume II: Wildlife Resource. Canadian Wildlife Service report to Parks Canada, Calgary, Alberta. 254 pp.

Vendl, M.A. and N.D. Smith. 1977. Sedimentation in glacier-fed Peyto Lake, Alberta. Annual Meeting, North-Central Section, Geological Society of America.

Vroom, G.W. 1974. Grizzly and wolf observations by Park Warden G.W. Vroom. File report, Warden Service, Banff National Park. 80 pp.

Vroom, G.W. 1975. Grizzly activity and denning information, Banff National Park. File report, Warden Service, Banff National Park. 74 pp.

Westhaver, A. 1984. Position analysis paper on management of special resource protection areas in Banff National Park. Warden Service, Banff National Park. 6 pp.

White, C. 1984. Interim fire management plan, Banff National Park. Warden Service, Banff National Park. 268 pp.

White, C. 1985a. Wildland fires in Banff National Park 1880-1980. Parks Canada Occasional Paper 3: 106 pp.

White, C. 1985b. Fire and biomass in Banff National Park closed forests. MSc thesis, Colorado State University, Fort Collins. 202 pp.

Whyte, J. and C. Harmon. 1982. Lake Louise — a diamond in the wilderness. Altitude Publishing, Banff, Alberta. 128 pp.

Wiebe, P. 1984. Lake Minnewanka test netting results. Parks Canada, Western Regional Office, Resource Conservation Section. 15 pp.

Wilson, D.E. 1982. Wolverine. *In* H.A. Chapman and G.A. Fieldhammer (eds.), Wild Mammals of North America, Johns Hopkins Press, Baltimore. pp. 613-628.

Wilson, I.R. 1984. Banff townsite peripheral land use study - heritage resources. Report to Parks Canada by I.R. Wilson Consultants Ltd., Calgary, Alberta. 65 pp.

Wilson, M.V.H. 1985. letter to G. Morgan, Thurber Consultants, Victoria, British Columbia.

Wilson, M.V.H. 1986. personal communication. University of Alberta, Edmonton.

Wilson, T.E. 1972. Trail blazer of the Canadian Rockies. Glenbow - Alberta Institute Historical Paper 3: 54 pp.

Wright, A.H. and A.A. Wright. 1949. A handbook of frogs and toads of the United States and Canada. Comstock, New York.

Yeo, B. 1985. personal communication. Historical Architecture Section, Parks Canada, Calgary, Alberta.

Yonge, C. 1983. Castleguard 1983: No sign of an end. Alberta Speleological Society Expedition Report.

Young, G.J. and A.D. Stanley. 1976. Canadian glaciers in the International Hydrological Decade program, 1965-1974: No. 4 Peyto Glacier, Alberta. Fisheries and Environment Canada, Inland Waters Directorate, Scientific Series 71: 59 pp.

Young, S.P. 1944. The wolves of North America. Part I. Their history, life habits, economic status and control. American Wildlife Institute, Washington, DC. 385 pp.

Index

Agroelymus bowdenii, 22, 108
Agroelymus mossii, 22, 107, 108
Agroelymus turneri, 22, 108
Agrostis humilis, 22, 109
Agrostis mertensii, 22, 108
Agrostis thurberiana, 109
Alexandra River, 9, 17, 27, 31, 32, 42, 48, 52, 107
Altrude Creek, 8, 42, 43, 69, 110
AL1, 39, 103
American Bittern, 44, 55, 108, 110
American Coot, 85
American Kestrel, 55
American Robin, 55
Amery, 107
Anthracite, 42, 93, 99, 102
Arctomys Creek, 33
Arenaria longipedunculata, 108
Arenaria longipes, 109
Arnica Lake, 30
Arnica longifolia, 109
Arnica parryi, 108, 109
Artesian Springs, 13
aspen, 38
Aster xmaccallae, 23, 107, 108
AZ1, 88, 89
Baker Creek, 42, 47, 61, 75, 78, 89, 93, 99, 102
Baker Lake, 41, 49, 67, 109
Bald Eagle, 44, 108, 110
Banff airfield, 8, 38, 75, 88, 107
Banff townsite, 11, 13, 35, 43, 48, 52, 56, 67, 79, 82, 85, 86, 96, 97, 101, 102, 103, 113
Bankhead, 93, 99, 102, 104
Bare Mountain, 70
Bare Range, 31, 78
Barred Owl, 47, 108, 110
Barrow's Goldeneye, 85
Basin Spring, 11, 12
Bath Creek, 9, 99
Big Springs, 7
Bighorn Falls, 14, 110
Bird Community 1, 44, 47, 48, 55
Bird Community 13, 47, 55, 88
Bird Community 3, 48, 55
Bird Community 4, 44, 48
Bird Community 5, 48
Bird Community 9, 44, 48, 55
bison, 66, 82, 113
BK1, 39
BK4, 39
BK6, 39
black bear, 69, 86, 108, 110, 113
Black Swift, 8, 47, 107
Black Tern, 51, 110
Black-backed Woodpecker, 47, 109, 110
Black-capped Chickadee, 55
Bohemian Waxwing, 55
Bonaparte's Gull, 51, 110
Boom Creek, 29
Boom Lake, 39
Boom Mountain, 27
Botrychium lanceolatum, 23, 105, 108
Bourgeau Lake, 29, 53, 56
Bow Falls, 13, 18, 93, 110
Bow Lake, 6, 15, 17, 18, 24, 85, 105
Bow Pass, 23, 25, 26, 30, 33, 34, 39, 67, 90, 105
Bow River, 9, 13, 15, 16, 17, 19, 38, 39, 41, 42, 44, 48, 49, 51, 53, 56, 59, 61, 73, 75, 76, 82, 85, 86, 88, 89, 91, 105, 107, 108, 109, 110
Bow Valley, 7, 16, 28, 36, 37, 42, 43, 44, 47, 48, 49, 51, 52, 53, 55, 56, 57, 59, 63, 66, 67, 69, 70, 74, 75, 76, 79, 82, 85, 86, 88, 89, 102, 103, 105, 110, 112, 113, 115
Bow Valley Parkway, 9, 43, 75, 79, 96, 97, 103
BP1, 39
Braya humilis, 23, 108
Brewster Creek, 7, 16, 67, 99, 102
Brewster Rock, 25
Bridal Veil, 13
Bromus altissimus, 24, 108
Brown-headed Cowbird, 55
Bryant Creek, 11, 30, 48, 53, 59, 61, 67, 73, 99, 108
Bull Trout, 41, 115
BV1, 103
BV3, 88, 89
Calliope Hummingbird, 47, 55, 107
Canada Goose, 85
Carex bipartita, 24, 109, 110
Carex crawei, 24, 108
Carex deflexa, 24, 108, 109, 110
Carex enanderi, 24, 110
Carex glacialis, 24, 110
Carex illota, 25, 105, 110
caribou, 63, 109, 114
Carrot Creek, 75, 78, 93, 99, 105, 111, 112
Cascade Mountain, 11, 78, 79, 89, 107
Cascade Power House, 9, 33, 66
Cascade River, 9, 16, 35, 36, 38, 39, 48, 52, 57, 67, 73, 91, 97, 103, 105
Castilleja hispida, 25, 108
Castilleja Lake, 22
Castle Junction, 7, 8, 43, 69, 75, 79, 85, 86, 89, 93
Castle Mountain, 9, 27, 28, 34, 78, 107, 115
Castleguard Cave, 6, 7, 13, 40, 107
Castleguard River, 6, 7, 11, 32, 63
Cave and Basin, 1, 31, 40, 41, 42, 43, 53, 85, 102, 104, 114
Cave Spring, 11, 13
CA1, 39
cedar, 32
Chephren Lake, 31, 33
Chernozemic, 10, 11, 109, 114
Chestnut-collared Longspur, 52
Chipping Sparrow, 55
Cirrus Mountain, 13, 82, 107
Citadel Mountain, 26, 29
Citadel Pass, 78
Clearwater Lake, 67
Clearwater Pass, 12, 33, 39, 63, 73, 109
Clearwater River, 9, 13, 16, 38, 39, 49, 57, 59, 61, 103, 107, 111, 115

Cliff Swallow, 53, 109
Columbia Icefield, 6, 7, 13, 17
Common Crow, 55
Common Flicker, 55
Common Goldeneye, 85
Common Grackle, 52
Common Merganser, 85
Common Nighthawk, 55
Common Yellowthroat, 55
Cooper's Hawk, 44, 55
Copper Mountain, 102
Corral Creek, 89, 93, 97, 99, 107
Cory Pass, 25, 26
cougar, 61, 63, 88, 89, 108, 109, 110
Crepis atrabarba, 25, 107, 108
Crowsnest Pass, 25, 26, 27, 28, 29, 31, 32, 33
Cryosolic, 10
Cuthead Creek, 73
Cutthroat Trout, 41, 108
CV1, 39
C1, 35, 37, 55, 88, 105, 107, 108, 109, 110, 113
C12, 36, 39, 107, 109
C13, 89
C15, 89, 90
C16, 35, 38, 55, 88, 105, 107, 109, 110, 113
C17, 55
C18, 89
C19, 89
C20, 89
C21, 89
C22, 55
C23, 36, 39, 40, 108
C24, 10
C26, 8, 35, 38, 109
C3, 88
C30, 89
C33, 36, 38, 108, 109
C9, 36, 39, 89, 105, 108, 109
Dace, 41, 42, 109, 112
Dark-eyed Junco, 55
David Creek, 108
deer, 63, 66, 69, 73, 79, 88, 105, 107, 108, 109, 110, 115
Devil's Gap, 8, 38, 93, 108
Devon Lakes, 53, 109
Dicanthelium acuminatum, 25, 109
Dipper, 85, 109, 110
Divide Creek, 24, 25, 73, 93
Dolly Varden, 41
Dolomite Creek, 16, 38, 73
Dolomite Pass, 40, 63
Dormer River, 11, 34, 39, 49, 73
Douglas fir, 9, 16, 35, 37, 55, 88, 105
Douglas Lake, 38, 89
Draba albertina, 25, 105, 109
Draba fladnizensis, 25, 108
Draba longipes, 26, 109
Draba reptans, 26, 108
Draba ventosa, 26, 108, 110
Drosera linearis, 26
Eagle Mountain, 21, 26
east gate, 36, 37, 39, 43, 49, 69, 70, 75, 76, 79, 112
Egypt Lake, 67
EG1, 38
Eldon Springs, 13
elk, 57, 63, 66, 69, 70, 73, 75, 82, 88, 105, 107, 108, 109, 110, 113
Elk Lake, 41
Engelmann spruce, 38, 39
Epilobium luteum, 26, 105
Epilobium saximontanum, 26
Erigeron purpuratus, 26, 108, 110
Eriophorum callitrix, 27, 109
Erysimum pallasii, 27, 107, 108, 109, 110
Fairholme Range, 105
Fatigue Pass, 23, 29, 109
fern, 23, 29, 30, 33
Fish Lake, 41
Fisher, 59, 109
Fivemile Creek, 16, 93, 96, 108, 109
Flints Park, 34, 53, 67, 73, 93, 105
Forbes Creek, 25
Forster's Tern, 51
Fortune Springs, 13
Fortymile Creek, 16, 44, 82, 93, 107, 108
fossil, 9, 115
Franklin's Gull, 51, 107, 108, 110
Freshfield Creek, 9
Freshfield Glacier, 17, 99
Freshfield Icefield, 17
frog, 42, 105, 107, 109, 110
Front Ranges, 10, 11, 36, 38, 44, 49, 57, 61, 63, 67, 70, 79
FR1, 39, 103
Gable Mountain, 9, 11
GA1, 37, 38, 88, 107
Ghost River Wilderness Area, 32
Giant Steps, 13, 108
Glacier Lake, 8, 32, 33, 36, 89, 108
Glacier National Park, 22, 26, 30, 40, 56
Glacier River, 8, 9, 89
goat, 63, 69, 70, 73, 79, 82, 105, 107, 108, 109
Goats Eye, 6
Golden Eagle, 53, 105, 108
Golden Plover, 49, 110
golf course, 36, 43, 75, 76, 82, 93, 96, 103, 110
Goshawk, 44
grassland, 10, 11, 25, 26, 28, 35, 36, 47, 51, 52, 55, 82, 88
Graveyard Flats, 23, 27, 31, 52, 107, 111
Great Gray Owl, 47, 109
grizzly bear, 67, 105, 108, 109
GT2, 11
Habenaria unalascensis, 27, 107, 108
Haiduk Lake, 89
Haplopappus uniflorus, 27, 107, 108
Harlequin Duck, 85
Harrison Lake, 38
Hawk Owl, 43, 47, 108, 110
HC1, 39
HD1, 8, 38, 103, 105
HD2, 36
HD3, 38

HD4, 36, 88, 107
Healy Creek, 7, 16, 21, 22, 23, 27, 30, 31, 32, 43, 48, 52, 56, 61, 75, 93, 99, 102, 110
Healy Pass, 109
Hector Lake, 9, 15, 39
hemlock, 32
Herbert Lake, 15, 18, 43
Hieracium cynoglossoides, 27, 107, 108, 110
Hillsdale, 9, 22, 25, 30, 36, 37, 47, 75, 88, 93, 96, 107, 109, 111, 112
Hoary Bat, 56
hoodoos, 9, 35, 105, 107, 108, 109, 110
horse stable marsh, 44, 76
Horseshoe Lake, 89
House Wren, 48, 109
Howse Pass, 17, 93, 97, 101, 102, 104
Howse River, 8, 9, 16, 17, 27, 29, 36, 38, 48, 97, 108
H10, 90
H11, 90
H13, 35, 36, 88, 108, 110, 113
H14, 11
H19, 35, 37, 88, 107, 113
H4, 11
H5, 11
H6, 35, 36, 55, 88, 105, 107, 108, 109, 110, 113
H7, 35, 36, 55, 105, 107, 108, 109, 113
H9, 89, 90
IB3, 88, 89, 108
Ice River, 6
Icefields Parkway, 13, 15, 18, 19, 43, 105
Indian Grounds, 1, 51, 75, 82, 85, 93, 107, 111, 112
Indian paintbrush, 25
Indianhead Creek, 9, 11, 31, 34, 70, 73, 107
Ink Pots, 12, 13, 18, 107
Ishbel, 9, 88, 89, 96, 107
JNP, 8, 10, 16, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 47, 48, 49, 51, 57, 59, 61, 63, 66, 67, 85, 88, 89, 90
Johnson Lake, 15, 16, 18, 35, 37, 44, 51, 53, 67, 79, 85, 91, 93, 99, 105
Johnston Canyon, 7, 13, 18, 47, 99, 107, 111, 112
Johnston Creek, 7, 9, 13, 16, 27, 28, 36, 37, 48, 56, 61, 67, 75, 88, 102, 105, 107, 112
Juncus biglumis, 27, 108
Juncus parryi, 28, 108, 109, 110
Kidney Spring, 11, 12, 40
Kootenay National Park, 6, 25, 26, 32, 37, 39, 40, 47, 59
Kootenay Plains, 27, 29, 38
Lake Agnes, 27, 28, 29, 30
Lake Helen, 24, 51
Lake Louise, 9, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 39, 47, 49, 52, 69, 70, 82, 85, 86, 89, 93, 97, 99, 102, 104, 107, 108, 111
Lake Minnewanka, 8, 9, 15, 18, 27, 36, 37, 51, 53, 67, 79, 85, 88, 91, 103, 108
larch, 33
Larch Valley, 23
Larix lyallii, 33, 39
Lewis' Woodpecker, 43, 47, 110
Lincoln's Sparrow, 55
Lipalian Mountain, 90
Listera caurina, 28
Lithophragma glabrum, 28, 107
Lithophragma parviflorum, 28, 107, 108
Loess, 8, 36, 38, 108, 109
Long-eared Owl, 47, 55, 107, 109, 110
Lost Horse Creek, 22, 49
Louise Creek, 16, 89
Lyell Icefield, 17
Magnolia Warbler, 48, 110
Mallard, 85
Mallard Duck, 55
Malloch Creek, 93
Martin Creek, 13, 14, 16, 18, 38, 107
Marvel Lake, 29, 41, 90, 108, 111
Marvel Pass, 26, 28, 108
Massive, 9, 93, 107
McConnell Creek, 38
McNair Pond, 43, 93
MC1, 39
Meadow Creek Springs, 13
Melica spectabilis, 28, 110
Merlin, 44, 109
Mew Gull, 51
Middle Springs, 11, 12, 18, 23, 27, 40, 93, 113
Mistaya River, 7, 8, 15, 16, 23, 39, 42, 43, 44, 48, 52, 59, 67, 73, 85, 108
Mitella breweri, 28, 108, 110
ML2, 88, 89
Molar Creek, 89
Monarch, 109
moose, 69, 73, 107, 108, 109, 110, 112
Moraine Creek, 89, 107
Moraine Lake, 15, 18, 23, 56, 89, 107, 108
Mount Athabasca, 26, 108
Mount Aylmer, 23
Mount Bourgeau, 21, 23, 26, 27, 28, 29, 78, 82, 109
Mount Brett, 29
Mount Coleman, 27, 30, 32, 82, 107
Mount Cory, 29, 79, 96, 109
Mount Edith, 25, 109
Mount Kentigern, 34
Mount Murchison, 29
Mount Norquay, 21, 25, 28, 29, 36, 79, 82, 86, 108, 112
Mount Patterson, 32
Mount Peters, 78
Mount Revelstoke National Park, 26
Mount Rundle, 29, 82, 110
Mount Sarbach, 89
Mount Saskatchewan, 13, 24
Mount White, 10, 11
Mount Willingdon, 14
Mount Wilson, 23, 30, 78, 82
Mountain Chickadee, 55
Mourning Dove, 55
MQ1, 38
Muleshoe, 47, 67, 75, 85, 93, 103
Muskrat, 66, 105, 108, 109, 110

Mystic Lake, 39, 41
Mystic Pass, 67
Nashville Warbler, 52, 110
NG1, 88, 90, 108, 109
Nigel Creek, 13, 90, 108
Niverville Meadows, 17
Norman Creek, 43, 107
North Saskatchewan River, 8, 9, 16, 17, 19, 27, 31, 36, 37, 38, 39, 42, 44, 48, 49, 52, 55, 59, 63, 67, 79, 85, 86, 91, 103, 107, 108, 115
North Saskatchewan Valley, 7, 13
Northern Phalarope, 51, 105, 109, 110
Northern Yellowthroat, 55
NT3, 88, 90, 105, 107, 113
Num-ti-jah, 15, 18, 103, 104, 105
NY1, 37
NY3, 8, 36, 37
Orange-crowned Warbler, 55
orchid, 27, 28
Osmorhiza chilensis, 28, 108
Osprey, 53, 105, 107
Otter, 61, 110
Owen Creek, 7, 8, 93, 99, 102, 108
Owl Lake, 31, 108
O10, 89, 90
O11, 36, 39, 107, 109
O19, 36, 38, 39
O2, 35, 37, 38, 109, 110, 113
O5, 35, 37, 55, 105, 107, 108, 109, 113
Palliser Pass, 89, 93, 97
Palliser Range, 70, 75, 78, 105
Palm Warbler, 52, 110
Panther Corners, 75
Panther Falls, 13, 108
Panther Mountain, 11, 34
Panther River, 11, 13, 16, 18, 27, 30, 31, 38, 39, 49, 53, 56, 57, 67, 70, 73, 75, 78, 93, 97, 103, 108, 111
Paradise Creek, 16
Paradise Valley, 13, 22, 27, 107
Parker Ridge, 24, 26, 49, 82, 108, 111
Pedicularis racemosa, 29, 108
Pellaea atropurpurea, 29, 110
Pellaea glabella, 29, 108, 109
Penstemon fruticosus, 29
Peregrine Falcon, 49, 108, 109, 110
permafrost, 10, 11, 38, 105, 107, 108, 109, 114
Peters Creek, 11, 73, 78, 90
Peyto Glacier, 18, 105
Peyto Lake, 15, 18, 85, 105
Pied-billed Grebe, 53, 85, 110
Pilot Pond, 15, 16, 43
Pine Siskin, 55
Pinus contorta, 37, 39
Pinus flexilis, 37, 108
Pipestone Pass, 67, 99, 102, 109
Pipestone River, 16, 39, 42, 56, 63, 67, 73, 89, 90, 107
Poa lettermanii, 29, 110
Poa stenantha, 29, 108
Polygonum austiniae, 30, 108
Pool Springs, 11
Populus tremuloides, 38
PP2, 38
PP3, 38, 103
PP4, 9
PP6, 103
PP7, 103
Prairie Falcon, 49
Protection Mountain, 102
Pseudotsuga menziesii, 35, 37
Ptarmigan Lake, 24
Pteridium aquilinum, 30, 109
PT3, 37, 88, 108, 109
PT4, 38
PT5, 39
Pygmy Shrew, 56
Quartz Ridge, 21, 22, 26, 31, 78
Rainy Bay, 53, 85
Rampart Creek, 17, 43
Ranunculus grayi, 30, 107, 109
Ranunculus occidentalis, 30, 109
Ranunculus verecundus, 30, 105, 108, 109, 110
Red Breasted Merganser, 110
Red Deer Lakes, 6, 67, 90, 93, 109
Red Deer River, 8, 9, 14, 33, 38, 39, 47, 48, 57, 67, 70, 73, 89, 91, 96, 97, 103, 109, 110
Red fox, 59
Red-breasted Merganser, 49, 108
Red-eyed Vireo, 48, 55
Red-necked Grebe, 53, 55, 85, 105, 108, 110
Red-winged Blackbird, 55
Redearth Creek, 9, 28, 61, 67, 69, 73, 75, 89, 93
Redoubt Lake, 51, 53, 109
Redoubt Mountain, 27, 28, 30
Rhododendron lapponicum, 30, 107
Ribes laxiflorum, 30, 108
Ring-necked Duck, 55, 85
Rock Wren, 48, 109
Rockbound Lake, 25, 33
Rorripa tenerrima, 31, 108
Rough-legged Hawk, 49, 110
Ruffed Grouse, 55
Rumex pauciflorus, 31, 108, 110
Rusty Blackbird, 48, 110
Sabine's Gull, 51, 110
salamander, 16, 43, 105, 110, 114
Salix boothii, 31, 109, 110
Salix lanata, 31, 107
Sanderling, 51
Saskatchewan Crossing, 8, 16, 17, 23, 24, 25, 26, 27, 36, 37, 38, 39, 44, 47, 48, 49, 52, 66, 67, 97, 101, 102, 108
Saskatchewan Glacier, 8, 13, 17, 24, 107, 108
Sawback Creek, 67
Sawback Lake, 25, 67
Sawback Range, 21, 29, 30, 33, 107, 109
Saxifraga flagellaris, 31, 107, 110
Saxifraga nelsoniana, 31, 108
Saxifraga nivalis, 32, 108
Say's Phoebe, 52
Scotch Camp, 31, 61, 75, 93, 96, 99, 109
Sentinel Pass, 32
SF1, 10, 39, 105, 107, 108, 109

Shadow Lake, 44
Sharp-tailed Sparrow, 52, 107
sheep, 63, 69, 70, 73, 76, 78, 105, 107, 108, 109, 110
Short-billed Dowitcher, 51
shrew, 107, 108, 110
Siffleur River, 16, 38, 51, 59, 63, 73, 75, 103, 109, 114, 115
Siffleur Wilderness Area, 23, 63
Silver-haired Bat, 56
Silverhorn Creek, 39
Simpson Pass, 22, 23, 24, 25, 28, 32, 99, 101
Skoki, 67, 99, 103, 104, 109
snail, 40, 42, 110
snake, 43, 109, 110, 114
Snow Creek, 14, 24, 26, 27, 30, 32, 39, 61, 67, 93, 97, 109
Snowflake Lake, 14, 15, 109
Snowy Owl, 52, 108
Solitary Vireo, 55
Sorbus sitchensis, 32, 108, 110
Southeast Lyell Glacier, 33
Sparganium hyperboreum, 32, 110
Spray River, 9, 13, 23, 28, 29, 39, 42, 48, 49, 53, 56, 57, 59, 67, 73, 99, 102, 103, 109
SP1, 39
Stellaria umbellata, 32, 109
Steller's Jay, 48
Stoney Creek, 10, 11, 56, 67, 105
Stoney Squaw Mountain, 27, 28, 82
Storm Mountain, 26, 103
Sulphur Mountain, 9, 11, 12, 18, 40, 79, 82, 88, 102, 109, 112, 113
Sundance, 6
Sunset Pass, 25, 30, 107
Sunshine, 16, 19, 22, 23, 24, 28, 31, 61, 69, 73, 75, 76, 79, 99, 103, 109, 112, 114
Sunwapta Pass, 23, 27, 108
Survey Peak, 32
Swainson's Thrush, 55
Swamp Sparrow, 52, 108
S8, 89
Taylor Creek, 89
Taylor Lake, 32, 41
TA3, 8, 38
Thuja plicata, 32
Trans-Canada Highway, 9, 15, 19, 43, 63, 66, 69, 75, 76, 79, 82, 96, 97, 107, 108, 110, 113, 114, 115
Tree Sparrow, 52, 107, 109
Tree Swallow, 55
Trumpeter Swan, 49, 110
TR1, 38
TR2, 39
Tsuga heterophylla, 32
Tunnel Mountain, 9, 13, 29, 47, 75, 79, 82, 86, 110, 112
Twin Cairns, 23, 24, 27
Twin Lakes, 41, 90
Two Jack Lake, 15, 25, 53, 85
Tyrrell Creek, 78, 93
Upland Sandpiper, 51, 107, 109
Upper Hot Springs, 11, 40
Vaccinium ovalifolium, 33
VD2, 88, 89, 108, 113
Vermilion Lakes, 12, 15, 16, 18, 31, 40, 42, 43, 44, 47, 48, 49, 51, 52, 53, 61, 66, 67, 69, 73, 75, 76, 78, 85, 91, 93, 96, 99, 110, 111, 112, 113
Vermilion Pass, 8, 32, 34, 47, 99, 110
Vermilion Spring, 13
Veronica catenata, 33, 105
Vesper Sparrow, 55
Victoria Glacier, 24, 25
Viola glabella, 33
VL1, 8, 39
VL4, 103
vole, 56, 107, 110
Wapta Icefield, 17, 18
Warbling Vireo, 55
Warden Lake, 15, 16, 85
Water shrew, 56
Waterfowl Lake, 15, 41, 51, 52, 85
Waterton Lakes National Park, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 38, 47, 59, 61
weasel, 59
Wenkchemna Glacier, 15
Western Flycatcher, 48, 107, 109
Western Meadowlark, 52, 107, 109
Western Tanager, 55
Western Wood Peewee, 55
WF3, 39
WF4, 38
Whiskey Creek, 75, 79, 82, 85, 96, 110
Whistling Swan, 49, 110
Whitegoat Wilderness Area, 23, 25, 26, 27, 28, 30, 31, 32, 63
Whitehorn Mountain, 27, 90, 107
WH1, 39
WH2, 88, 90, 108
Wigeon, 85
Wigmore Creek, 11, 93
Wigmore Lake, 14, 51, 67, 85, 105
Willmore Wilderness Park, 10, 25, 26, 30, 31, 32
Willow Flycatcher, 55
Wilson's Phalarope, 51, 110
wolf, 1, 57, 88, 105, 107, 109, 110
wolverine, 61, 89, 107, 108, 109, 110
Wolverine Creek, 79, 93, 99
wolves, 57, 59, 69, 88, 89, 108, 109
Wood Duck, 43, 44, 105, 110
Woodsia glabella, 33, 109
WW1, 9
Ya Ha Tinda, 14, 36, 38, 57, 75, 76, 93, 96, 99, 103, 110, 111, 115
Yellow Warbler, 55
Yellow-bellied Sapsucker, 55
Yellow-rumped Warbler, 55
Yoho National Park, 6, 24, 37, 39, 40, 48, 59